SEDA

NSW Wind Energy Handbook 2002



Sustainable Energy Development Authority of NSW (SEDA) ABN 80 526 465 581
Level 6, 45 Clarence St, Sydney Australia
PO Box N442, Grosvenor Place NSW 1220
wind@seda.nsw.gov.au
www.seda.nsw.gov.au
Ph + 61 2 9249 6100
Fax + 61 2 9299 1519

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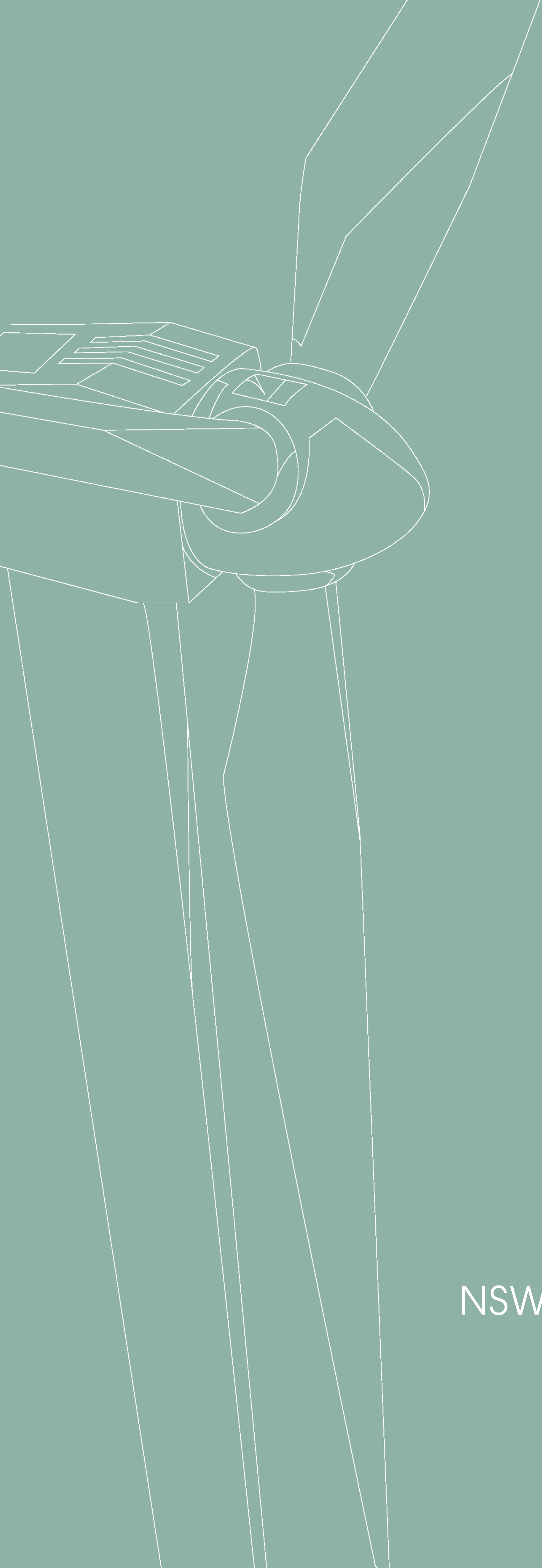

NSW wind energy handbook

'Farmers and rural communities will continue to play an important role in the development of NSW's wind energy resources. Appropriately sited and designed wind farms using sound commercial arrangements deliver benefits to all parties directly involved, including landowners, as well as to the environment and the communities in which they are situated. The NSW Farmers' Association is committed to promoting the sustainable and appropriate development of renewable energy resources and encourages rural communities to consider the potential benefits of wind farms. The Association supports the Sustainable Energy Development Authority's initiative to provide information to landowners in the Wind Energy Handbook.'

Jonathan McKeown
Chief Executive
NSW Farmers' Association

'The Local Government and Shires Associations fully support the development of renewable and ecologically sustainable forms of energy generation and encourage councils to support and facilitate wind generation proposals in their local areas wherever feasible. Wind power generation can provide an important boost to local and regional economies. This handbook will greatly assist councils to better understand the environmental and economic benefits that wind power generation can bring, and also to help them to ensure that developments are in accordance with best practice and the principles of ecologically sustainable development.'

Cr Peter Woods OAM
President
Local Government Association of NSW

Cr Mike Montgomery
President
Shires Association of NSW

'Wind power is already a A$12 billion global industry which can help us combat climate change, support the community and create jobs across New South Wales. Wind power offers genuine hope for our future. The Australian wind industry wants to join the global boom, and Greenpeace supports their push to increase the national Mandatory Renewable Energy Target from 2% to 10% by 2010. SEDA's Wind Energy Handbook is a brilliant tool to bring diverse groups together to help create thousands of regional jobs by building wind farms and factories. NSW delivered the Sydney Olympics, so why not a world class wind industry?'

Corin Millais
Campaign Coordinator
Greenpeace Australia Pacific

From the NSW Minister for Energy

The New South Wales Government is at the forefront of national efforts to address the adverse impacts of climate change. Already NSW is home to 52 percent of the nation's renewable energy capacity. Wind is the fastest-growing energy technology in the world, and NSW is taking steps to capture the advantages of new investment and job creation by further developing the renewable energy industry in this State.

Studies have shown that NSW can support up to 1000 additional Megawatts of wind energy. Already NSW boasts the largest wind monitoring network in Australia, with more than 25 sites. Our background windspeeds are comparable to northern Europe, the home of the international wind industry, and our wind farms have easy access to the National Grid.

The NSW Wind Energy Handbook will help to ensure that our wind resource is developed to the highest standards of environmental and social planning. I am proud of this NSW Government initiative that engages all levels of industry and the community towards climate protection and economic opportunity.

Kim Yeadon MP
NSW Minister for Energy

From SEDAs Executive Director

Since its inception in 1996, SEDA has been integral in the growth of the renewable energy industry in New South Wales. With this publication, we focus our energies on wind and the significant economic contribution this technology can deliver for the future. SEDA is in a unique position to facilitate the sustainable growth of the industry, from strategic partnerships to assisting landholders and regional communities.

SEDA has long been committed to eliminating barriers to the development of new, renewable energy, and so we have worked closely with industry and government bodies to bring together all the relevant, up-to-date information on the wind energy industry in Australia.

We encourage you to capitalise on the mature technology, experienced operators and proven development processes that are described in this handbook. With your continued support and contributions, this vital industry will thrive. We welcome your interest and collaboration to expand the opportunities for wind development in New South Wales.

Mark Fogarty
Executive Director, SEDA

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PACIFIC POWER INTERNATIONAL

CVC REEF

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Australian Wind Energy Association
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Country Energy
CSIRO - Wing Energy Research Unit
CVC REEF
Eraring Energy
Greenpeace Australia Pacific
Hickory Hill Wind Energy
Hydro Tasmania
Id Planning
NSW Coastal Council
NSW Department of Land and Water Conservation
NSW Department of State and Regional Development
NSW Department of Urban Affairs and Planning
NSW Farmers' Association
NSW Local Government and Shires Associations
Pacific Power International
PB Power
Primergy
Stanwell Corporation
Sustainable Energy Authority of Victoria
Sustainable Energy Industry Association

Contents

To help readers keep pace with future changes and explore specific issues in more detail, the handbook provides references to websites, reports and other documents throughout. In particular, two important documents should be used in conjunction with this guide:

> The Australian Wind Energy Association's **Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia** explains the steps that should be taken to develop appropriate wind energy projects in Australia. The guidelines are primarily intended for use by large-scale wind energy developers, but will also provide a useful reference for a range of other stakeholders.

> The NSW Department of Urban Affairs and Planning's **EIA Guideline for Wind Farms** outlines a consistent approach to environmental impact assessment for wind energy developments under the **Environmental Planning and Assessment Act 1979**. It lists issues that may need to be considered in an assessment.

Picture courtesy of Eraring Energy

Introduction

This handbook has been prepared by the Sustainable Energy Development Authority (SEDA), a New South Wales Government agency created in 1996 to reduce the level of greenhouse gas emissions in the state.

The handbook provides a comprehensive kit of up-to-date, accurate and impartial information on all aspects of wind energy development in NSW. It has material for all participants involved in commercial wind energy development, including **decision makers, developers, investors, landholders** and the **local and wider community.** The handbook does not specifically cover small scale domestic wind energy technology.

Wind is the fastest-growing energy technology in the world. Over the last six years the average annual growth in sales of wind turbines internationally has been 40 per cent. In preparing this handbook SEDA aims to help participants take an informed approach to wind energy projects, and ensure the ongoing sustainability of the wind energy industry.

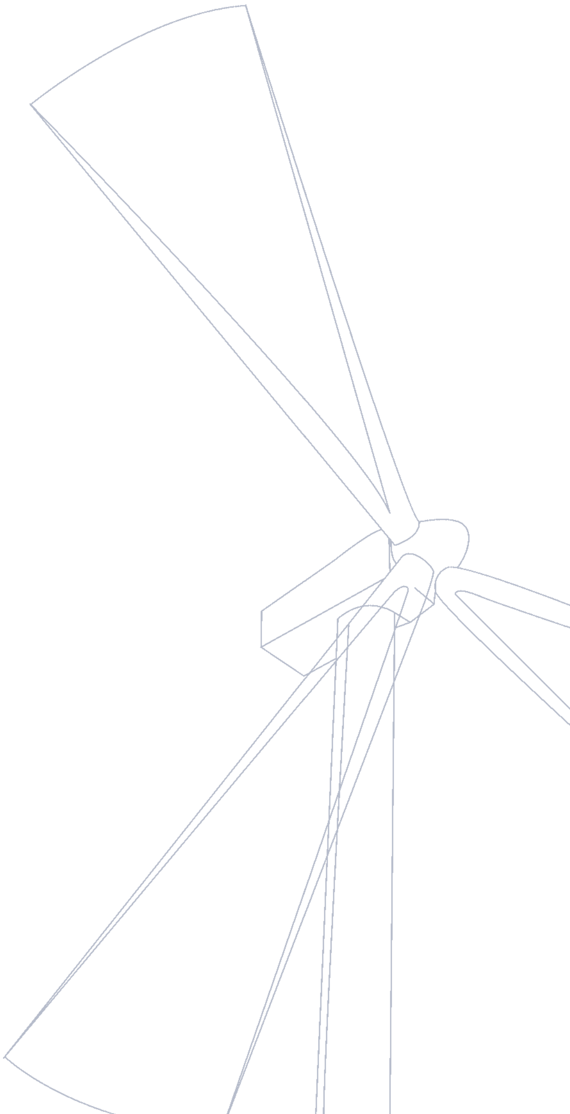
There is great potential for wind energy development in NSW. Background wind speeds here are comparable to northern Europe, and difficulties in site acquisition and planning are less common than in Europe, the USA and some other Australian states. NSW has:

- vast areas of open land accessible and suitable for wind developments (63 per cent of the population live in Sydney and 74 per cent of our landmass is used for agricultural activity);
- an extensive transmission network linked to the national grid, providing easy access for wind farms;
- a growing number of 'wind friendly' property owners and local planning authorities;
- a defined process for planning approvals;
- the biggest wind monitoring network in Australia (over 25 sites);
- exciting potential - well over 1,000 MW capacity for wind energy with just 17 MW installed.

SEDA is setting the pace in providing proactive government support for this growing industry. SEDA's initiatives include:

- a comprehensive wind monitoring program;
- project development assistance;
- financial support and export assistance;
- liaison with other state and federal government agencies.

SEDA is committed to the sustainable development of the wind energy industry in NSW, and works with a range of partners to maximise the benefits to the NSW community and the environment.



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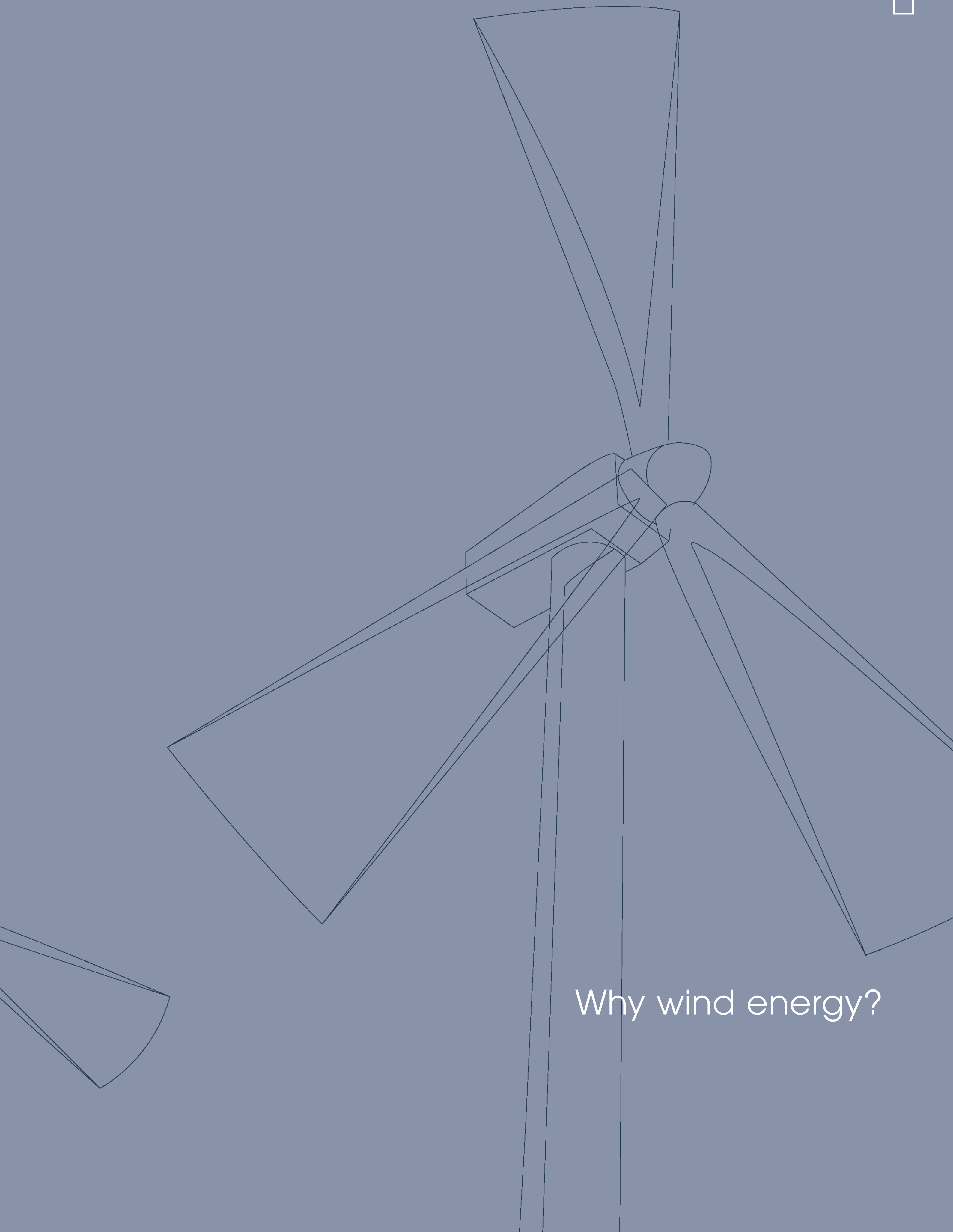
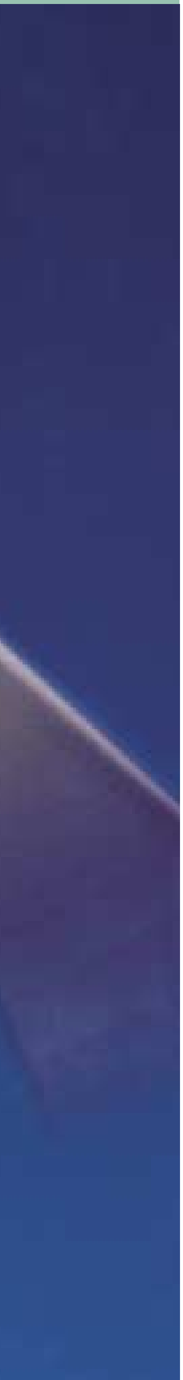


Why wind energy?


Picture courtesy of Eraring Energy



Why wind energy?

> > The benefits of wind energy are compelling: low greenhouse impact, stimulation of economic growth, job creation, enhanced diversity of electricity generation, and short development timeframes. The fuel is free, abundant and inexhaustible.

Wind is the global energy success story of the 21st century, and the pace of progress has been rapid for such a young industry. In both 1999 and 2000, growth rates exceeded expectations, and a record capacity of turbines was installed internationally. By the end of 2000, the total installed capacity of global wind energy was more than 18,000 megawatts (MW).

Country	Wind Energy Capacity (MW) installed
Germany	6,113
USA	2,555
Spain	2,402
Denmark	2,297
India	1,220
Britain	406
China	340
Japan	150
Australia	70
Egypt	63
Morocco	54

Source: Windpower Monthly

Consumers are demanding environmentally sound energy solutions, and are empowered by the opportunity to contribute personally to greenhouse gas abatement. Electricity retailers recognise the marketing edge that offering green energy products provides.

Wind energy can reduce costs, especially to communities reliant on diesel-powered generation, and offers security of supply in times of growing world energy costs.

Wind energy also has substantial benefits for NSW as a whole. It can augment the distribution and transmission network by providing longevity and improved power quality, and can effectively supplement the state's aging generation assets. Unexpected load growth and changing demand patterns require new generation capacity to be built as soon as possible. Ideally, this new capacity should offer long-term stability of price and availability as well as greenhouse gas reduction. Wind energy is ideally placed to offer such improvements progressively, at the same time as creating investment, manufacturing and regional growth over the next 10 to 15 years in rural areas of NSW. This fits in with the objectives of environmentally sustainable development embraced by local government in NSW.

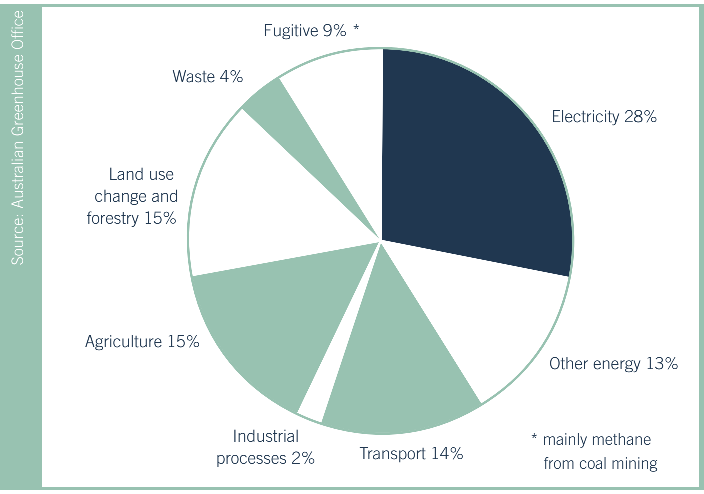
These issues will be described in greater detail throughout the handbook.

Environmental benefits

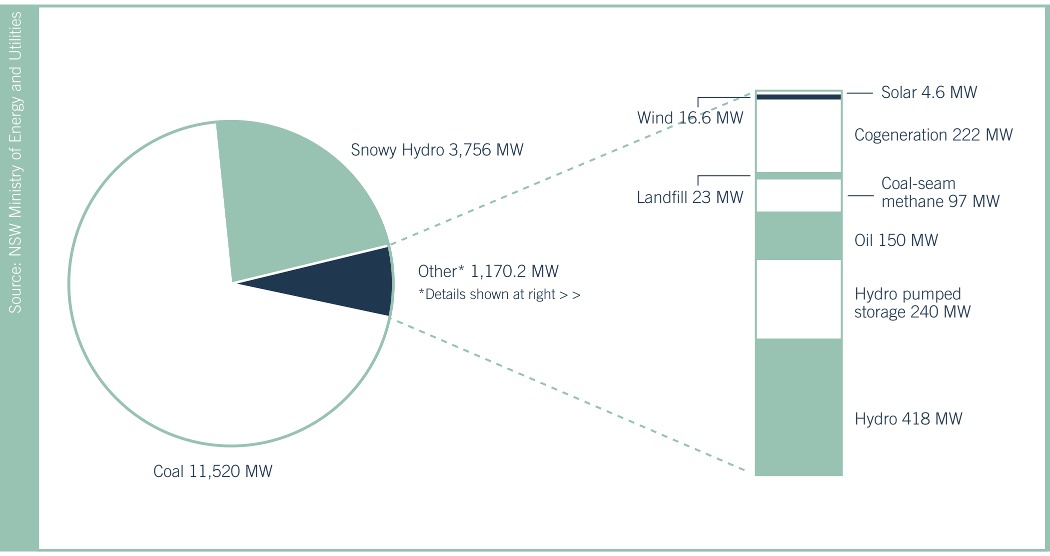
Most scientists agree that global climate change caused by excessive greenhouse gas emissions – the ‘enhanced greenhouse effect’ – is one of the most serious environmental problems facing the world today. Likely impacts include increases in temperature and in the frequency and severity of extreme weather events (see Climate Change Projections for Australia).

In NSW, where more than 90 per cent of electricity is generated from coal, 28 per cent of greenhouse gas emissions are due to the generation of electricity. Generating electricity from wind energy causes no greenhouse pollution. Wind energy is one of the most advanced and commercially available renewable energy technologies and is an important part of international moves to mitigate climate change.

Wind energy also avoids other environmental impacts associated with coal-fired electricity generation. These impacts include emissions of oxides of nitrogen and sulfur, which cause acid rain and other atmospheric pollution.



1995 NSW greenhouse gas emissions by sector



Installed NSW generation capacity by fuel type

> > The enhanced greenhouse effect

The glass walls and roof of a greenhouse let in heat and light from the sun, but trap heat energy inside, so the temperature is warmer inside the greenhouse than outside. The gases that make up the earth's atmosphere, in particular carbon dioxide (CO_2), act like a greenhouse, trapping heat and making the earth warmer.

This is a natural process – without it the earth would be 33°C colder! However, human activity is adding too much carbon dioxide and other 'greenhouse gases' to the atmosphere, enhancing the greenhouse effect and potentially resulting in global warming. Burning fossil fuels like oil and coal for energy releases CO_2 into the atmosphere and accounts for about one quarter of the greenhouse gas production in the developed world.

For more information on the greenhouse effect, see **www.dar.csiro.au/cc/default.htm**

> > Climate change projections for Australia

A 2001 study by the CSIRO predicts that as a result of climate change Australia will be hotter and drier in coming decades. The study's predictions include:

> annual average temperatures will rise by 0.4–2°C over most of the continent (compared to 1990 levels) by 2030, and 1–6°C by 2070;

> lower rainfall will be experienced in parts of south-eastern Australia; wetter conditions are possible in eastern Australia in summer and inland in autumn; in areas where average rainfall increases or stays the same, more frequent or heavier downpours are likely, and there will be more dry spells in regions where average rainfall decreases;

> sea level will rise at a rate of between 0.8 and 8.0 cm per decade, reaching 9–88 cm above the 1990 level by the year 2100;

> coral reefs, alpine ecosystems, mangroves and wetlands will be lost, with tropical forests, savannas, deserts and native grasslands also under threat;

> forest ecosystems will expand in a carbon dioxide–enriched atmosphere, but these gains may be offset by warmer conditions;

> tropical pests such as the Queensland fruit fly will spread southwards; other temperate pests, like the light brown apple moth, may move to cooler areas;

> for agriculture, there will be a trade-off between the positive impact of higher carbon dioxide levels and the negative effect of lower rainfall and higher temperatures. Higher carbon dioxide concentrations will increase plant productivity and the efficiency with which plants use water. A moderate rise in temperature will increase plant growth in temperate areas. Warmer conditions will reduce frost damage to many crops. However, fruit trees need cold weather to set fruit, so some fruit yields may decline. Wheat yield will rise with warmer conditions if rainfall doesn't change. A rainfall decline of 20 per cent with temperature increases of more than 1°C will lower yield.

For full details of the study, see **www.dar.csiro.au/res/cm/projections.htm**

Opportunities for rural and regional NSW

Most wind energy developments in NSW will be in rural and regional areas. Wind energy is especially attractive to these communities because of the potential for employment, industry development, income for landholders, and supplementing existing tourist attractions.

An independent study commissioned by SEDA (ACIL Consulting 2000) shows that **employment** created by sustainable energy developments tends to be concentrated in rural and regional areas. The study found that:

- manufacturing wind turbines creates 3–6 jobs per megawatt of installed capacity;
- installation creates 0.5–0.8 jobs per megawatt;
- the operation and maintenance of wind turbines creates 0.05–0.5 jobs per megawatt.

For more information about the study see **www.seda.nsw.gov.au/pdf/employmentindicators.pdf**

The potential for a wind turbine **manufacturing industry** in Australia will grow as the demand for wind power increases, becoming viable when 50 to 100 megawatts of turbines are installed here annually. Some components such as wind turbine towers for commissioned projects are already being sourced from local manufacturers, and developers are committed to using local resources. NSW is a logical base to enter new markets in the Asia Pacific region, an attractive option for manufacturers currently exporting from Europe. A new industry will result in new jobs, investment in regional areas, and new skills for the NSW workforce which will be widely sought after as the wind industry gathers momentum globally.

Land for wind farms in NSW is generally leased for the forecast life of the wind farm. This creates a secure long-term income stream for landowners, which complements income from farming activities.

Wind farms are a new and unusual addition to the NSW rural landscape – interesting to the public as an example of cutting edge technological expertise, as a tangible demonstration of commitment to positive environmental outcomes, and to many, for their aesthetic character. Such interest may create benefits for the local community in the form of increased **tourism**, although this may diminish as wind farms become an established feature of the landscape.

Picture courtesy of Greenpeace Australia Pacific

Benefits for a range of stakeholders

Wind energy developments have benefits for many stakeholders, from developers and landholders to the community as a whole.

For **NSW**, wind energy is attractive for its contribution to:

- the State's efforts to reduce greenhouse gas emissions and meet energy supply policy objectives, including increased energy security and diversity;
- investment and employment in the manufacturing sector.

For **regional communities**, wind energy projects are attractive because:

- they provide opportunities for employment and regional development;
- the potential for a local manufacturing industry offers further opportunities for growth in employment, investment and new skills.

For the **broader community**, wind energy is attractive because:

- it is visibly 'green', offering environmental benefits through greenhouse gas abatement and reduced air pollution, and is consistent with widely held values of sustainability;
- of all the renewables, the cost of supply is most comparable to traditional methods of energy generation; and it is one of the most easily understood and trusted renewable energy sources.

For **landholders** wind energy projects are attractive because:

- they can provide a secure long-term income stream which complements income from other land uses such as farming;
- adverse impacts are temporary and reversible as sites can be easily restored.

For **electricity retailers** wind energy is attractive because:

- as a form of distributed generation, it offers greater network efficiency;
- it provides marketing and promotional opportunities, and experience with emerging technology;
- it helps meet demand for renewable energy created by Green Power customers; and helps the company comply with NSW Retailer Licence Compliance Conditions and Emissions Benchmarks, and with the Mandatory Renewable Energy Target (see section 3, page 37).

For **owners, operators and developers of energy projects,** wind energy is attractive because:

- the capital cost of a wind energy development is low relative to other renewable energy sources; the construction phase is short compared to other types of generation; turbines require low and predictable maintenance; and operational costs do not change according to fuel price fluctuations;
- wind farms are a modular development, with opportunities to add or replace turbines progressively;
- it adds diversity to generation capacity;
- wind farms can be installed close to location of demand, minimising or avoiding transmission losses;
- land purchase is not usually required and resource ownership is not an issue (usually wind energy developments co-exist with agricultural activities).

Drawbacks

In the past some wind farms have attracted negative publicity because of noise, impact on birds and visual amenity, and community groups have been formed to actively campaign against wind energy projects. Wind turbine technology and 'best practice' industry standards have now evolved to the point where the adverse impacts of a wind energy development can be minimised (see appendix B).

However, as a source of energy supply, wind power still has some drawbacks:

- it depends on a resource which is variable in quantity (although generally predictable in the long term);
- without an associated storage system it must be supplemented by generation from other sources;
- lack of experience with the complexities of connecting to distribution and transmission networks can cause problems, as is also the case with other types of 'distributed' generation;
- it is not fully accepted and proven in Australia as a low-risk investment;
- compared to conventional fossil fuel generation, it still has a high capital cost, and hence a higher price per unit;
- the current reliance on imported machines puts developers at the mercy of exchange rate fluctuations;
- communities may be apprehensive about the local impacts of developments.

Most of these disadvantages can be overcome as experience is gained. The key long-term issues that may limit the growth of wind energy in NSW are:

- **Pricing:** The cost of generating electricity from wind is at least twice that of coal-fired generation in NSW. This is partially offset by market and regulatory incentives, but any future reductions in the retail price of electricity could affect the competitiveness of wind generation.
- **Regulation:** An appropriate regulatory framework for wind energy will incorporate market mechanisms to reflect the environmental advantages of wind farms, as well as their benefits to the State's electricity distribution network.

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> > Public attitudes to wind farms

The 2000 International Environment Monitor Survey found that around nine out of ten Australians believe that long-term climate change is happening (Market Attitude Research Services 2000). The survey also found that 78 per cent of Australians were willing to pay more for their electricity if it were generated from renewable sources.

A Scottish study (Dudleston 2001) has explored how local residents felt about wind turbines near their homes both before and after they were installed. The sample for the survey was drawn from residents living within 20 km of wind farms in Scotland.

The results were generally positive, with people living closest to the wind farm being most likely to return positive feedback. The proportion of people who expected to experience problems caused by the development (40 per cent) was much higher than the proportion who actually did report experiencing problems after construction (9 per cent). Actual noise caused by the turbines or the visual impact of the wind farm did not feature as issues for the large majority of respondents. Only 2 per cent said they disliked the wind farm because it was noisy, and although 12 per cent had expected to experience a problem with noise, only 1 per cent had actually experienced a problem.

Only 14 per cent of respondents said they would be concerned if extra turbines were added to the existing wind farm, reflecting a generally positive attitude towards potential future development.

The Danish Wind Turbine Manufacturers Association (Damborg & Krohn 1998) has analysed a number of surveys of public attitudes to wind turbines from around the world. This analysis indicates that internationally, public support is very high – for renewable energy sources in general and for wind power in particular. The level of public support varies, however, with people's local experience with wind power.

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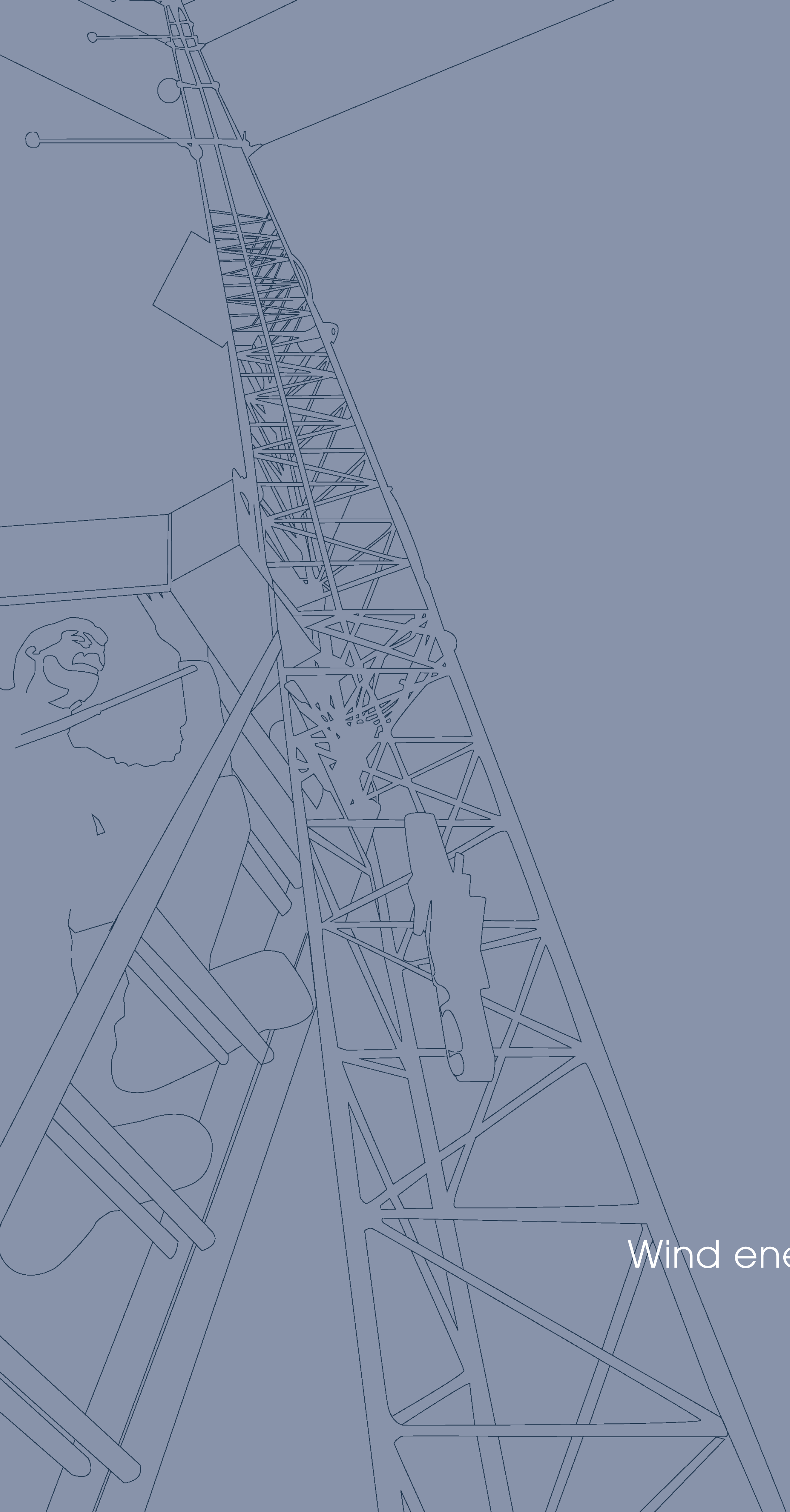


Wind energy basics

2

Wind energy basics

> > This section introduces the basic elements of the wind energy industry — the wind itself, the turbines that generate electricity, the distribution system or electricity 'grid', and the range of organisations that might be involved in owning or operating a wind energy development.

The wind

The earth's uneven surface produces differences in air temperature that create differences in air pressure. When the difference is great enough, the air moves from the area of high pressure to the area of low pressure trying to keep equilibrium. This air movement is wind, and the bigger the pressure difference, the faster the wind blows. Wind is also influenced by the rotation of the earth.

For each doubling of wind speed there is an eightfold increase in the available energy. Generally wind speed increases with height above ground level, as the effect of friction from the earth's surface decreases.

Wind speed in any particular location is governed by two main factors. Firstly, there is a 'background' wind speed, generally resulting from prevailing weather systems and local meteorology, which may include sea breezes, storms or other short-term events. Secondly, this background wind is modified by local influences such as funnelling through valley systems, or acceleration over topography and variations in surface cover. These local influences, which may change over short distances, can be substantial, even halving or doubling potential wind energy yield at any particular location.

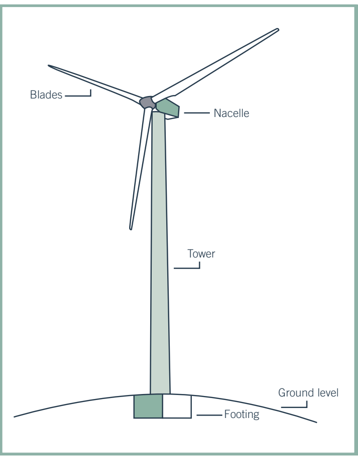
See Good wind resource in NSW (Section 3 page 32) for a description of wind dynamics in NSW, and Wind monitoring (Section 4, page 54)

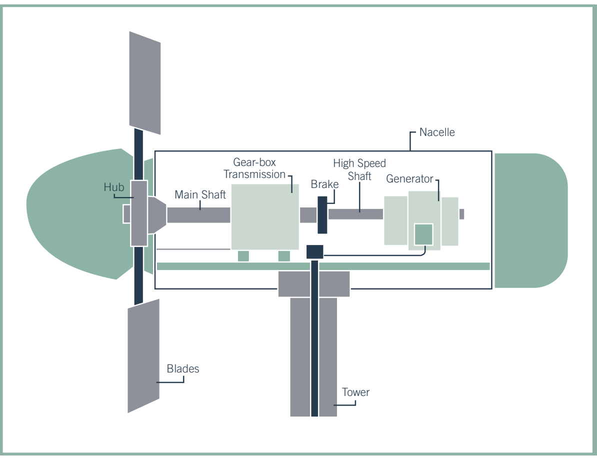
Anatomy of a wind turbine

The energy of the wind is converted into mechanical energy by using the wind to turn blades attached to a rotor. As the wind passes over the blades, their shape creates differences in pressure which cause the rotor to turn. The rotor is attached to a generator and as the rotor turns, its mechanical energy is converted into electrical energy.

The conventional ‘horizontal axis wind turbine’ (referring to the axis on which the blades and hub rotate), sometimes known by its acronym ‘HAWT’, consists of four main elements: rotor, nacelle, tower and footing.

Rotor: The rotor consists of the hub and blades, and the shaft connecting them to the gearbox and generator. These are the main moving parts of the turbine. Most turbines have three blades, commonly made of carbon fibre, plastic, fibreglass or epoxy, which are aerodynamically designed for maximum energy generation and minimum noise. Fixed-speed turbines automatically adjust their blade angle to maintain constant rotation speed in all wind conditions. Variable-speed turbines rotate faster as the wind speed increases, and use power electronics to ensure correct voltage and frequency of output (see box). Blades may exceed 30 metres in length, giving a rotor diameter of 60 to 80 metres.

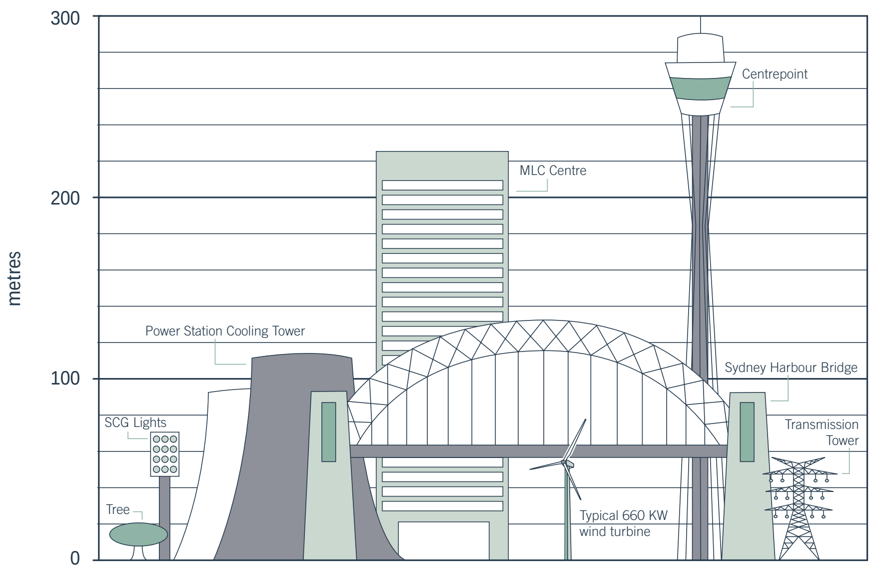




Nacelle: Meaning ‘small boat’ in French, the nacelle sits on top of the tower and houses the gearbox and generator. The hub supporting the blades is attached to it at one end. Nacelles are of varying sizes, depending mainly on the design and size of the generator, and may weigh between 20 and 70 tonnes. The nacelle revolves horizontally on the tower (‘yawing’) to allow the rotor to face the wind regardless of its direction.

Tower: Towers are typically between three and five metres in diameter at the base and taper to about two metres at the top. Their height varies with the size of the generator and the length of the blades: large generators may have towers as high as 100 metres. The height is necessary to gain access to higher and less variable wind speeds than those at ground level. All NSW developments have used tubular steel towers, with an off-white coloured coating. Earlier overseas developments used steel lattice towers.

Footing: Footings are generally a concrete slab below ground, 7–12 metres or more in diameter, and 1–2 metres in depth. Specifications for the footing will vary depending on the turbine size, design wind speeds, manufacturer’s specifications and local geotechnical conditions. The base is topped with a circular plinth which contains the turbine tower ‘holding down’ bolts. Once the footing is installed and the tower erected, the excavation is back-filled and the area landscaped to the base of the tower.



> > Fixed-speed and variable-speed wind turbines

Most wind turbines are **fixed-speed machines**. Fixed-speed turbines idle (turn slowly) until a 'cut-in' wind speed is reached, typically 4 to 5 m/s (metres per second). 'Cut in' is the point at which the generator starts to produce electricity. Beyond that point, the rotors quickly reach constant operating speed of 15 to 30 revolutions per minute. The control system of the turbine maintains the operating speed by constantly adjusting the pitch of the blades in response to changes in wind speed. All turbines automatically stop rotating when they reach a 'cut-out' wind speed, typically 25 to 35 m/s.

Variable-speed machines have similar 'cut-in' and 'cut-out' characteristics. However, they differ from fixed-speed turbines in that between 'cut-in' and the rated maximum speed of the turbine, rotor speed increases with rising wind speed. Above 'rated' and below 'cut-out' wind speed, rotor speed is either fixed or marginally variable.

All wind turbines have a maximum design wind speed, beyond which point the machine may suffer damage. The operational 'cut-out' speed is set safely below the design wind speed.

Whether fixed or variable speed, all wind turbines are designed to maintain a reasonably stable quality of power output regardless of variations in wind speed. Fixed-speed turbines achieve this by using aerodynamic blade pitch and stall mechanisms to keep the blade rotating at a constant speed. Variable-speed turbines use power electronics to convert the constantly changing blade rotation speed into a stable quality of power.

Lifespan

The **technical design life** of a wind turbine is the amount of time it can continue to work as long as maintaining and servicing it are more cost-effective than replacing it with a new machine. All modern commercial wind turbines have a technical design life of more than 20 years, although certain components may need to be replaced or serviced during this time. For example, gearboxes will require an oil change at least every three years and highly stressed components such as bearings may need to be replaced after 10 years.

Energy payback

The energy payback is the length of time an operating turbine will take to generate the amount of energy used in its manufacture, installation, operation, maintenance, repair and decommissioning.

A 1997 study by the Danish Wind Turbine Manufacturers Association shows that a Danish 600 kW wind turbine will recover all the energy spent in its manufacture, maintenance, repair and decommissioning within about three months of its commissioning. Within its 20-year design lifetime a wind turbine will supply at least 80 times the energy spent in its manufacture, installation, operation, maintenance, repair and decommissioning. (Although decommissioning a turbine requires energy, recycling the metal parts will recover slightly more energy than that required for the decommissioning process.)

Turbine output and wind farm capacity

As with any technology, a basic understanding of the terminology and standard units of measurement is important to appreciate the context of developments.

Wind turbines are classed by their **rated output**, which is expressed in watts (W). The rated output is the maximum electrical power a generator will provide when running at optimum performance. For example a 600 kilowatt (kW) wind turbine exposed to optimum wind conditions will provide 600 kW of electrical power.

Similarly the size of a wind farm is usually referred to by its **total installed capacity**, which is the combined rated output of all the turbines in the farm. For example, the Blayney Wind Farm, near Bathurst, consists of 15 turbines each with 660 kW rated output and thus has an installed capacity of 9.9 megawatts (MW). To put this in context, the coal-fired Eraring power station has four generators each rated at 660 MW, providing a total installed capacity of 2,640 MW.

The **electrical energy** produced by a wind turbine in any given period is usually measured in kilowatt hours (kWh). This is the same unit that appears on household electricity bills to measure electricity consumption. So for example a 600 kW wind turbine operating at its rated output for one hour will generate 600 kWh. To put this in context, 600 kWh is enough energy to power a 60 W light bulb for 10,000 hours. The average NSW household consumes approximately 7,300 kWh of electricity per year.

The **theoretical maximum output** of a turbine or wind farm over a whole year is simply the total installed capacity multiplied by 8,766 (the average number of hours in a year). However, in a real life situation the annual energy output of a wind turbine will always be less than its theoretical maximum output over the year. This is due to a number of factors, the main one being that the wind does not blow all the time at the speed for which the turbine was designed.

The **capacity factor** of a wind turbine, or an entire wind farm, is the actual annual energy output divided by the theoretical maximum output. Commercially viable wind farms in NSW will generally have a capacity factor of between 25 per cent and 35 per cent. There are very few sites operating in the world with capacity factors greater than 40 per cent, with the highest in the world being the Tararua Wind Farm in New Zealand at just over 50 per cent. Generally countries such as Germany experience capacity factor percentages in the low to mid 20s.

The capacity factor of wind energy compares favourably with many forms of generation. For example, peaking hydro generators typically have a capacity factor of 12 per cent to 20 per cent and NSW coal-fired generators run at around 60 per cent capacity factor.

The **availability factor** is the percentage of time per year that the machine is available to generate electricity. Wind generation now enjoys excellent availability – typically over 99 per cent for the latest wind turbines.

The climate change benefits of wind farms are often expressed in terms of **greenhouse gas abatement**. This is based on the concept that each unit of electricity generated by a wind turbine and fed into the NSW transmission grid will avoid the need for a unit of electricity sourced from a conventional NSW generator. Most of the electricity in NSW is generated from coal-fired power stations, and on average approximately 1 kilogram of carbon dioxide is released into the atmosphere for each kilowatt hour of electricity produced.

Consequently every kilowatt hour of electricity from a main grid-connected wind farm can be attributed with 1 kilogram of greenhouse gas abatement. To put this in context, the Crookwell Wind Farm has a 4.8 MW capacity and is expected to save around 10,500 tonnes of CO_2 each year for the life of the project. This has the same relative benefit, in terms of greenhouse gas abatement, as taking 2,333 cars off the road for good.

Trends in turbine technology

There is a mature global industry in wind energy technology. Turbines are now in mass production in Europe, Asia and the USA, and there is potential for a manufacturing industry in Australia.

The most significant trend is the **increasing size** of individual machines. Turbines are now slower-spinning, with larger rotors placed at greater hub heights. This means more electricity can be generated with a smaller number of turbines.

In 1999 the average size of wind turbines commissioned internationally was 729 kW; in 2000 it rose to 800 kW, with nearly 40 per cent having a capacity of 1 MW or more; and in the foreseeable future, capacities are likely to exceed 2 MW. The trend to larger turbines has a number of benefits, including the ability to place more capacity in the 'hot spots' of topography, thus generating more electricity with fewer turbines. Higher hub heights also enable the turbines to take advantage of the greater wind speeds experienced further away from the ground.

Improvements in **materials technology** mean that turbines are lighter relative to their capacity. There have also been substantial improvements in **control and power regulation systems**, and 'direct drive' turbines have been developed that avoid the need for a gearbox.

Together with capacity and efficiency improvements, advances in technology are **reducing local environmental impacts**. Improvements to gearbox materials and blade profiles have dramatically decreased noise levels, while visual impact and blade glint are reduced by the use of improved surface coatings.

Turbines are now subject to International Electrotechnical Commission 61400 Certification. These standards establish a platform for turbine design and safety, power performance, noise measurement, mechanical load measurement, blade structural testing and power quality.

As **modular technology**, wind turbines offer significant flexibility. Projects may be developed in phases as the wind resource at a site is proven. And because not much time elapses between the turbine arriving on site and its commissioning, construction risks and finance costs are minimised. The modular nature of the technology also makes it particularly attractive as an export product, which can have the added advantage of creating local employment.

> > Potential for local manufacture

The world's largest manufacturers of wind turbines are based in Denmark, where the wind industry is one of the country's greatest exporters. Other significant manufacturers are based in Germany and the United States. The resulting transport costs, import duties, risk and exposure to exchange rate movements add to the cost of the equipment for Australian projects.

Establishing a turbine manufacturing industry in NSW will mean lower turbine costs for local developers, as well as lower freight costs. And with exchange rates favouring exporters, NSW manufacturers will be well positioned to take advantage of export opportunities in Asia, the Pacific and New Zealand. Lower labour costs may even mean export back to Europe is more economical than production in Europe itself.

By maximising the use of locally supplied equipment, project developers can reduce costs as well as provide economic benefits to Australia and the local community. All the towers for the major NSW wind farms were manufactured in Australia. At the time of writing a number of companies are proposing to manufacture entire wind turbines in Australia.

Small scale turbines of less than 100 KW are already successfully manufactured in Australia to local designs.

Help in sourcing locally manufactured equipment and services is available, free of charge, from the NSW Industrial Supplies Office (see **www.isonsw.com.au**)

Electricity transmission and distribution

Power transmission networks, or 'grids', are designed to distribute power from centralised generators out to consumers around the grid area. Power is usually generated as alternating current (AC) due to the design of most generators and is transported at very high voltages (for example, 500,000 volts) to minimise transmission losses. High-voltage transmission lines can be used to carry the power for hundreds of kilometres from the generator to an area of consumers. Here the power is transformed to a lower voltage for more convenient and cheaper transport over short distances.

In NSW high-voltage lines above 132 kilovolts (kV) are referred to as the 'transmission network' (refer to map on page 42). These lines are owned and operated by Transgrid, a state owned corporation. Lower-voltage lines are part of the 'distribution network', which is the responsibility of the four electricity retailers in NSW. See **www.tg.nsw.gov.au**

Like most renewable energy technology, wind power is usually installed as 'distributed' generation. This is relatively small-scale generation that is connected directly to the low-voltage distribution network.

Electricity cannot be stored easily on a large scale, so the fluctuating output of generators in the system must be constantly matched with the changing demand of power consumers. It works rather like a vast network of interconnected pipes with large pumps feeding water in at various locations, and millions of small taps being turned on and off at various locations around the network.

Such a careful balancing act can be disrupted by a sudden drop in generating capacity, or a large change in demand. This can cause a domino effect as sections of the grid are stressed beyond their capacity until they fail (or protection equipment is tripped), the pressure is transferred to another part of the grid, which also fails, and so on.


Picture courtesy of Eraring Energy

The use of a wind farm to improve the quality or efficiency of the local grid would offer significant savings for the grid operator due to deferred upgrade costs and improved efficiencies. There are currently no incentives offered by operators of the NSW grid in return for improvements in the quality or efficiency of the local grid that might result from a wind farm project, but work is being done in this area (see The NSW electricity grid in section 3, page 38).

Connecting to the grid

A range of electrical equipment is used for feeding generated electricity to the transmission system – the electricity 'grid'. Turbines generally generate electricity at between 400 and 690 volts. This voltage is stepped up to 11 kV or 33 kV by a **transformer** at each tower. The transformer and a high-voltage switch may be housed inside the tower, or mounted on a concrete pad beside the tower. The high-voltage switch units are connected by a 11 kV or 33 kV underground cable, linking them to a central switchyard, from where the electricity will be fed into the transmission network.

The process involved in connecting a wind farm to the grid depends on such factors as project size, local grid quality and the requirements of the relevant local distributor. Wind farm projects must be registered with the National Electricity Market Management Company (NEMMCO) as explained in section 3 page 33, and NEMMCO may impose requirements on the operation of the wind farm, depending on how the project is classified. The **local grid** may need upgrading to ensure that the output of the wind farm can be carried efficiently without jeopardising power quality on the grid (see box Technical issues for grid connection). The responsibility and cost of upgrading the local grid is generally negotiated between the project developer and the local distribution operator.

Finally a **grid connection agreement** is executed between the project developer and the local distributor. This agreement outlines the rights and obligations of each party and typically includes issues such as:

- connection to the grid – specifying responsibilities and costs to each party, and the conditions of connection approval;
- quality of supply – the quality of power required by the distributor;
- interruption to supply – conditions under which the wind farm may cease exporting to the grid, and the notice required by the distributor in such events; and
- availability of the grid – conditions under which the grid may not be accessible by the wind farm operator, and the implications of such events.

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> > Technical issues for grid connection

Any type of generator installed in a weak grid area could adversely impact the grid with effects such as:

> voltage flicker – short-lived fluctuations in the voltage of the grid can be caused by fluctuations in wind speed, and the starting or stopping of individual wind turbines;

> grid instability – power surges caused by the starting or stopping of wind turbines can trip the protection devices in the grid causing black-outs; and

> islanding – if part of the grid containing a generator becomes electrically isolated from the rest of the grid, the phases of the two sections will differ, and potentially large currents will be generated when they are re-connected.

Appropriate system design and grid integration can avoid these problems. For example, the design process should include a thorough analysis of existing load dynamics and fault levels to ensure that the wind farm does not inadvertently trip the network's protection devices. Weak grids can be 'reinforced' to avoid voltage flicker, and islanding problems can be prevented through appropriate electronic controllers which monitor the status of the rest of the grid and shut the turbine down in the event of islanding.

Wind farms can also be designed to provide benefits in weak grid areas by improving power quality. For example, modern wind turbines have in-built inverters and power electronics to actively control the 'power factor' of the grid. Power factor is a measure of the efficiency of the grid system. A high power factor indicates higher transmission efficiency, which effectively reduces the total amount of power required from generators in the grid to supply a given customer load. In addition to the resulting cost savings, a high power factor can provide environmental benefits where the main source of generation is non-renewable.

The business of wind energy

There are two main **sources of income** for a wind farm: the sale of electricity and the sale of its 'environmental attributes'.

The sale of the electricity itself works in the same way for a wind farm as for any other type of generator (see NSW Electricity Prices, Section 3 page 35). However, electricity from wind farms also has **environmental attributes** that can be valued financially in the marketplace. These attributes can take a variety of forms and are created through government regulation or consumer-driven programs. Examples of ways in which environmental attributes can be valued and sold include:

- **Renewable Energy Certificates (RECs)**: One REC represents one MWh of renewable energy eligible under the Renewable Energy (Electricity) Act 2001 (Cwlth). Electricity retail companies must source enough RECs to cover their obligations under the act, or face a penalty. A renewable energy project can be registered with the Office of the Renewable Energy Regulator, and certificates are then created detailing the number of megawatt hours of electricity it produces. At the time of writing one REC is worth around $35.
- **Green Power:** Electricity retailers sell Green Power to consumers at a premium and in return the retailers must source Green Power–approved electricity to meet the demand of these customers. As these customers pay a premium, retailers can afford to pay more for this 'higher-value electricity'. However, electricity retailers are required to surrender a REC (see above) for each sale of Green Power, which means that a retailer will pay a premium for ownership of both the Green Power right and REC.
- **Emission reduction rights:** These rights reflect the reduction in emissions of pollutants such as carbon dioxide that occurs when electricity is generated from wind power rather than fossil-fuel sources. At the time of writing, the main application of emission reduction rights was by electricity retailers to satisfy the licence compliance conditions required of all NSW electricity retailers. Various forms of carbon trading schemes have been proposed in Australia, as in other countries, as a mechanism to reduce greenhouse pollution. There are no schemes in place in Australia, although speculative purchases have occurred in the past.

See Market drivers for renewable energy in Australia (section 3, page 37), for more information on the programs behind these attributes.


Picture courtesy of Eraring Energy

Environmental attributes of electricity are usually created in units corresponding to a unit of electricity, or abated pollution. However, they can be 'stripped' from the actual electricity generation. In other words, the electricity generated from a wind farm may be sold to one party, while the green rights may be sold to a separate party, or retained by the generator.

Sale of the electricity and the value of the environmental attributes are formalised in **Power Purchase Agreements** (PPAs). These agreements usually specify a rate per kilowatt hour at which the power is sold, and state the total amount of power the wind farm is expected to produce. The output of large wind farms may be divided and sold to more than one buyer, or the environmental attributes sold separately, as described above.

The **kinds of organisations** which might get involved in owning, operating or investing in wind farm developments include:

- **energy generators:** Companies traditionally involved only in fossil-fuel generation or hydro are diversifying into wind power. Eraring Energy, formerly Pacific Power, now owns and operates both the Crookwell and Blayney wind farms.
- **energy retailers:** Companies such as Energy Australia have seen the benefits of building, owning and operating their own wind farms. Energy Australia developed a project at Kooragang Island, which now provides power to its Green Power customers.
- **private or publicly listed companies:** A wind farm may be owned and operated by any company, whether or not its core business is energy-related. An example is Pacific Hydro Ltd, which has developed the Codrington wind farm in Victoria. Often the company will contract the actual design, construction and operation to another firm to deliver a 'turnkey project'.

- **community groups or local landowners:** A group of individuals or organisations in a particular community could combine resources to install a small wind farm in their local area. This has been a common model in Germany and Denmark where favourable market conditions mean that farmers can install single turbines to provide a stable long-term income for retirement.
- c**orporate sponsors:** A number of corporate organisations around the world have seen the environmental and marketing benefits of being associated with a wind farm. In some cases the organisation contracts with the wind farm owner to buy the output, while in other cases the company directly invests in the project. Both The Body Shop and Sainsbury's, a UK-based supermarket company, own wind farms in the UK.
- **public investment funds:** Public funds have been established to invest money from private subscribers in wind power projects. An example is WindFund, a UK-based trust fund which invests exclusively in wind farm projects. In Germany these types of funds now represent the sixth-largest area of private capital investment with over $600 million raised in 2000.

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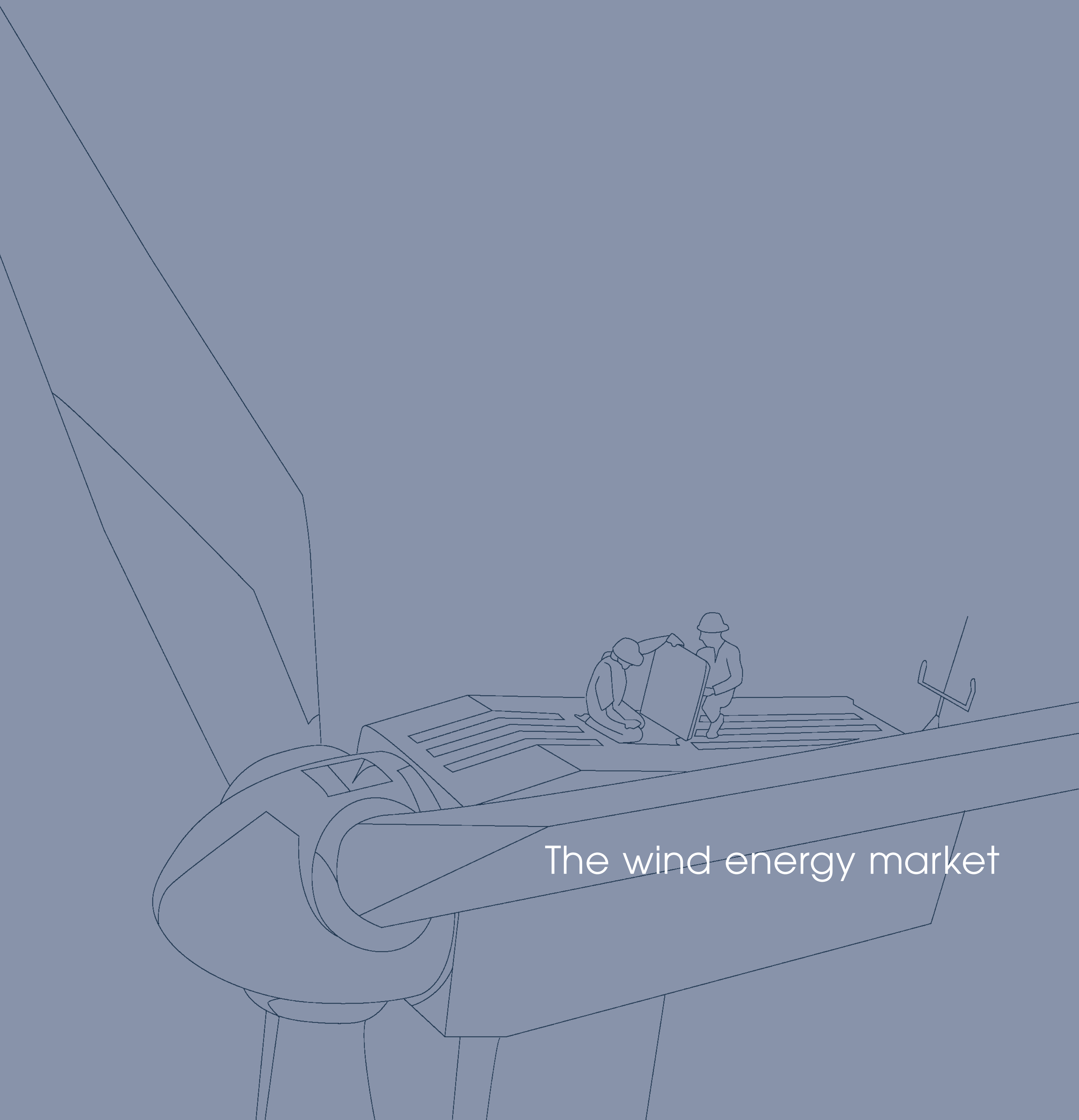
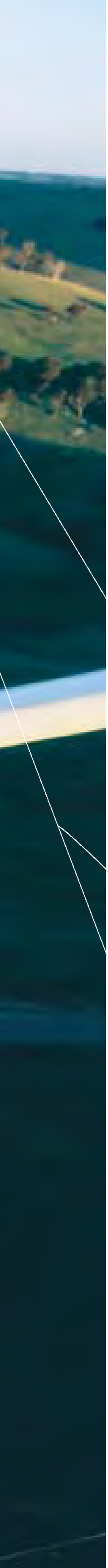


The wind energy market

Picture courtesy of Eraring Energy



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The wind energy market

> > The market potential for wind energy in NSW is high, with good wind resources and not much capacity yet installed. This section describes the structure and operation of the national electricity market, including initiatives designed to stimulate the growth of renewable energy, and opportunities for wind energy developers.

Market potential in NSW

NSW offers significant opportunities for wind energy development. There will be four commercial, grid-connected wind farms in the State by the end of 2001, providing a total installed capacity of just 16.6 MW. Potential capacity is estimated at well over 1,000 MW and the rate of development is likely to accelerate.

Current installations

The table below shows the history of wind farm development in NSW. The first commercial grid-connected turbine in the state was installed at Malabar in Sydney in 1983, and has recently been decommissioned. The latest development is the Hampton Wind Park, which consists of two 660 kW turbines connected to two 11 kV rural feeder transmission lines. This project is expected to demonstrate the network benefits of embedding wind energy capacity in a small rural grid, which will be applicable in many parts of NSW.

Wind farm location	Date commissioned	Number of turbines	Owner	Capacity (MW)
Malabar (eastern suburbs of Sydney)	Jan 1983 (de-commissioned 2000)	1 x 150 kW	Eraring Energy	0.15
Kooragang Island (near Newcastle)	Oct 1997	1 x 600 kW	Energy Australia	0.6
Crookwell (near Goulburn)	Aug 1998	8 x 600 kW	Eraring Energy	4.8
Blayney (near Bathurst)	Oct 2000	15 x 660 kW	Eraring Energy	9.9
Hampton (near Lithgow)	Oct 2001	2 x 660 kW	Hampton Wind Park Company	1.3
Lord Howe Island *	Due late 2002	1 x 300 kW	-	0.3

*SEDA released a public tender for this project in late 2001.

Wind energy capacity in NSW, as at end 2001

Future opportunities

At the Australian Wind Energy Forum 2001, the Australian Wind Energy Association (AusWEA) and Greenpeace Australia Pacific launched a target of 5,000 MW of wind energy capacity to be installed in Australia by 2010. According to AusWEA and Greenpeace, this target represents:

- an investment of A$10 billion, most of which would go into local manufacturing;
- 9,375 jobs to the year 2010;
- annual savings of approximately 15 million tonnes of carbon dioxide;
- 15,330 GWh of electricity, assuming a conservative 35 per cent 'capacity factor' (the proportion of time the turbines work to full capacity; see section 2, page 21).

See **www.auswea.com.au** and **www.greenpeace.org.au**

Good wind resource in NSW

The best wind resources in NSW are along the higher exposed parts of the Great Dividing Range and very close to the coast (except where significantly sheltered by local escarpments). This demonstrated background wind resource is more than adequate to develop the wind energy industry in NSW.

There can also be substantial local influences on wind characteristics in NSW. The best enhancements come from a combination of elevation, local topography and orientation to the prevailing winds. Such topography can act like aircraft wings, speeding up wind at the crests (a phenomenon which occurs at the sites of the Crookwell and Blayney wind farms), and this can be significant enough to compensate for a relative lack of background wind. On the western side of the Great Dividing Range the topographic influence can be substantial and, in general, this area offers the best prospects for wind energy development in NSW.

The other advantages of developing wind resources along the Great Dividing Range (such as the availability of suitable land and proximity to the grid) diminish the likelihood of developments in coastal areas or offshore. Offshore wind farms have been developed in Northern Europe because of the scarcity of available land sites, stronger wind resources at sea, and less turbulence. Increased construction and grid connection costs mitigate these advantages, however, and since NSW has a large range of potential land sites with excellent wind resources, offshore wind energy developments are unlikely in the near future.

SEDA's wind monitoring program (see page 42) has identified a number of areas in NSW with average wind speeds greater than 7 m/s (metres per second) – making development of these resources commercially viable in todays market. To put this in perspective, coastal areas of Ireland, Scotland, northern Denmark and areas of southern France have wind speeds of 7.5 m/s at a height of 50 m. Most of Denmark, northern Germany, the Netherlands, the UK, Ireland, France, Greece, and some areas of Spain, Portugal and Italy have wind speeds of over 6 m/s. Large areas of the European landmass have speeds of 4.5 m/s.

What is the National Electricity Market?

Electricity provision in Australia has been restructured along similar lines to other statutory utilities around the world. Reforms this decade have transformed the industry from one state-owned authority in each state into the three separate elements of:

- generation;
- transmission and distribution;
- retail supply.

The National Electricity Market operates in the ACT, NSW, Queensland, Victoria and South Australia. Market arrangements are defined in the National Electricity Code. The code includes the rules and procedures for the wholesale electricity market and the requirements for access to electricity networks.

The key organisations in the electricity market and their roles are described in the table below.

Organisation	Role
National Electricity Market Management Company (NEMMCO) **www.nemmco.com.au**	Manages and facilitates the National Electricity Market – the wholesale market for supply and purchase of electricity in the eastern states and South Australia.
National Electricity Code Administrator (NECA) **www.neca.com.au**	Supervises, administers and enforces the National Electricity Code.
Australian Competition and Consumer Commission (ACCC) **www.accc.gov.au**	Regulates the access regime for electricity networks in conjunction with jurisdictional regulators.
Independent Pricing and Regulatory Tribunal (IPART) **www.ipart.nsw.gov.au**	Regulator for NSW.

The players

Transmission and distribution networks in each state have been established as separate companies. These are statutory monopolies, regulated independently of the government. In NSW, Transgrid is responsible for the high-voltage transmission network, while each electricity retailer has a division which operates its local distribution network.

All **generators** are required to register with NEMMCO unless they are granted an exemption. Special rules exist to classify generators into categories depending on their size and whether they are required to participate in the wholesale electricity market.

Most wind farms are currently classified as **non-scheduled generators**. This category is defined as a generator or group of generators with an individual or aggregate rated capacity of less than 30 MW at one site. Non-scheduled generators are not required to have their output scheduled by NEMMCO (other exemptions may be granted by NEMMCO depending upon the characteristics of the generating plant).

The three other categories are:

- **Scheduled generators** – a generator or group of generators with an individual or aggregate rated capacity at or above 30 MW at one site; they are required to have their output scheduled by NEMMCO;
- **Market generators** – a generator whose output is not purchased in its entirety by a local retailer or by a customer located at the same network connection point. A market generator must sell all of its output through the spot market managed by NEMMCO (see below); and
- **Non-market generators** – a generator whose output is purchased in its entirety by a local retailer or customer located at the same network connection point; a non-market generator is not entitled to receive payment from NEMMCO for electricity sent out at its connection point.

The Australian Ecogeneration Association has developed a user guide for generators involved in the National Electricity Market. See **www.ecogeneration.com.au**

Electricity retailers buy from the market at the current (spot) price or direct from a generator under a long-term contract, and then sell the electricity to their commercial and domestic customers.

The electricity retail market in NSW moves to full 'contestability' from 1 January 2002. After this date, all retail electricity customers will be able to choose their electricity provider. The NSW Treasury Market Implementation Group is responsible for the development of retail competition policy. See **www.treasury.nsw.gov.au/mig.htm**

Wholesale trading: the 'spot' and 'forward' markets

Wholesale trading in electricity is conducted as a 'spot market' (see How does the 'spot market' work?). The spot market allows instantaneous matching of supply against demand, and plays a significant role in the economy in providing secure and reliable generation, transmission and supply of energy.

Overlaying this sometimes volatile spot market is the provision for hedging contracts between generators and retailers – the 'forward market'. These contracts are used to manage risk and provide predictability of prices. Most wind generators in todays market are likely to have a hedge contract, or **power purchase agreement** with a retailer, thus avoiding the spot market (see The business of wind energy in section 2, page 26).

How does the 'spot market' work?

Generators offer to supply the market with different amounts of energy at particular prices. From all offers submitted, NEMMCO selects the generators required to produce power and at what times throughout the day based on the most cost-efficient supply solution to meet specific demand. Generators can change their bids or submit re-bids according to a set of bidding rules.

Dispatch instructions are sent to each generator at five-minute intervals to schedule the amount of power to be produced. Demand for electricity varies from state to state depending on population and the industrial and commercial mix in that state. It also varies throughout the day. Prices are calculated for dispatch intervals in each region. The six dispatch prices calculated during each half-hour period are then averaged to determine the **spot price**. This spot price is used as the basis for billing participants within the NEM for all energy traded.

A maximum spot price is set under the National Electricity Code. This price cap is the maximum level at which generators can bid in the market. Spot price calculations and dispatch information can be accessed in real time through NEMMCO's website, see **www.nemmco.com.au/data/marketdata.htm**. Price information is also available on Teletext (pages 268–270).

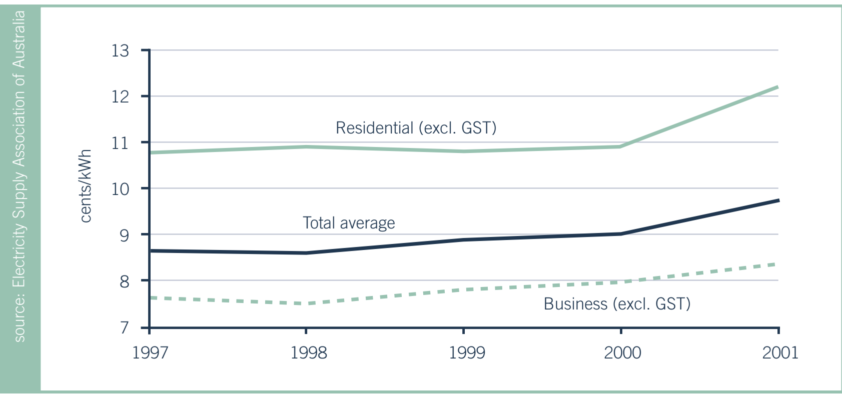
The National Electricity Code Administrator publishes weekly market analyses which set out the spot price for each trading interval in each region and compare it with the average for the previous week and the last quarter. Prices more than three times the weekly average are highlighted, and the demand and price forecasts published by NEMMCO four and 12 hours ahead of dispatch are compared with actual outcomes.

NSW electricity prices

Retail electricity prices in NSW break down as follows:

- around 40 per cent is the generation cost (the 'spot' or wholesale price to the retailer);
- high-voltage transmission costs make up around 10 per cent, and low-voltage distribution costs around 40 per cent; these costs are based on a formula which includes variables such as location, demand etc.;
- the retailer's margin usually comprises around 10 per cent.

Electricity sold to end-use customers is also subject to Goods and Services Tax (GST). GST is a value-added tax applied at 10 per cent. See **www.taxreform.ato.gov.au**



Average electricity prices in Australia, nominal, 1997–2001

Monitoring market trends: opportunities for developers

There are two important publications which analyse the state of the market and its prospects, and can thus highlight opportunities for wind farm developers.

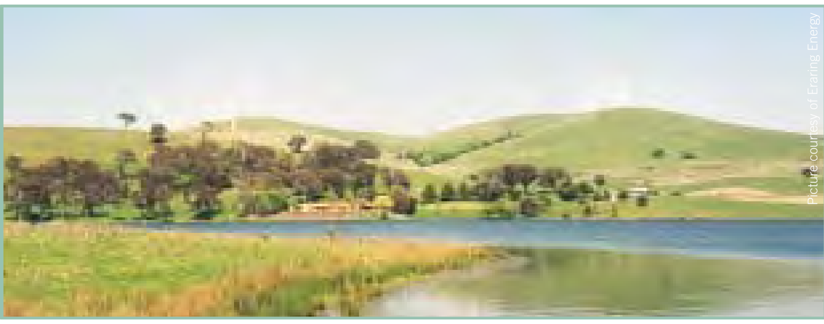
Each year NEMMCO publishes a **Statement of Opportunities**, which predicts market trends for the following 10 years. The statement outlines the system capability, and supply and demand forecasts for each jurisdiction in the NEM.

Specifically, the Statement of Opportunities includes:

- forecasts of electrical energy usage;
- details about generator capabilities;
- NEMMCO's assessment of the adequacy of energy supplies to meet demand;
- inter-regional transmission capabilities for exchange of energy between market regions;
- forecasts of ancillary service requirements to ensure secure operation of the system; and
- a summary of initiatives and proposed projects.

See **www.nemmco.com.au/publications/soo/soo3.htm**

The NSW Code of Practice 'Demand Management for Electricity Distributors', enforced by the Ministry of Energy and Utilities, requires distributors to issue an **Electricity System Development Review** each year. The review outlines the status of each network element and indicates where network constraints are forecast. Identification of these constraints may indicate opportunities for developers to install wind farms. See **www.energy.nsw.gov.au/industry_performance/networks**



Market drivers for renewable energy in Australia

Structural incentives

There are three structural incentives for retailers to buy electricity from wind energy developments. These incentives can provide income in addition to energy sales and network benefits alone (see The business of wind energy in section 2, page 26):

- Green Power - a consumer-driven accreditation program;
- a Mandatory Renewable Energy Target set by the Commonwealth Government;
- emissions benchmarks for retailers established by the State Government.

Green Power is a renewable energy accreditation system, giving consumers the choice to purchase electricity from renewable sources. The National Green Power Accreditation Program drives demand for renewable energy through consumer demand, building confidence in Green Power schemes offered by electricity companies through strict environmental and reporting requirements. All electricity retailers in NSW offer an accredited Green Power product.

For electricity retailers to gain accreditation, they have to meet and maintain certain requirements. These are to:

- use Green Power approved renewable energy sources (solar, wind, biomass, small scale hydro or hydro on existing dams);
- ensure that demand (from Green Power customers) meets supply;
- have financial statements independently audited annually;
- obtain 80 per cent of the renewable electricity they buy from new sources;
- ensure that Green Power electricity purchases are over and above any legislative renewable energy requirements.

Electricity retailers are independently audited annually to ensure compliance with these requirements. The audit reports are made available to the public.

Consumer demand for Green Power has grown steadily since the program started, with sales increasing from 40 GWh in 1997 to over 450 GWh in 2001. More than 14,000 new customers signed onto Green Power products in 2001.

Green Power will continue to operate with the aim of creating demand for renewable energy above and beyond any mandatory targets. The program and its accreditation rules are reviewed annually to keep them up to date in a changing market. It will continue to promote new generation sources. See **www.greenpower.com.au**

The **Mandatory Renewable Energy Target** has been stipulated by the Commonwealth Government under the Renewable Energy (Electricity) Act 2000. This target requires electricity retailers to purchase an additional 9,500 GWh (roughly 2 per cent) of their product from renewable energy sources by 2010, based on their 1997 output. The new law is designed to stimulate investment in the renewable energy industry and reduce greenhouse gas emissions. The Office of the Renewable Energy Regulator oversees the implementation of the target. See **www.orer.gov.au**

Retailers who offer a Green Power product will not be allowed to include the renewable energy generation for Green Power as part of the requirements under the Mandatory Renewable Energy Target. This is to ensure that the Green Power program continues to encourage renewable energy generation over and above mandatory targets, and that Green Power revenue is not used by retailers to satisfy these targets.

Renewable Energy Certificates (RECs) are a way of keeping track of how much renewable energy has been generated and who has generated it. RECs can be traded between companies or individuals, rather like shares. One certificate is created for every megawatt hour of renewable electricity produced.

At the time of writing, the Mandatory Renewable Energy Target was being discussed at the federal level. Some groups are lobbying to have the target increased, for example from 9,500 GWh to 13,000 GWh to best achieve the aims of the Renewable Energy (Electricity) Act 2000 (Cwlth).

Conditions for licensing electricity retailers are established by the Electricity Supply Act 1995 (NSW). Under these conditions, electricity retailers operating in NSW are required to develop strategies to reduce the emission of greenhouse gases. Strategies include purchasing electricity from renewable sources such as wind energy.

The NSW Ministry of Energy and Utilities outlines environmental guidelines that support these licence conditions in the Electricity Distributors' & Retail Suppliers' Licences Guidelines and Requirements Policy. This policy sets out individual emissions benchmarks for each retailer for each year. Although all retailers have put measures in place to reach these benchmarks, most are currently not meeting them. See **www.energy.nsw.gov.au**

The Independent Pricing and Regulatory Tribunal assessed retailer performance in meeting emissions benchmarks in the Electricity Distribution and Retail Licences: Compliance Report For 1999/2000. The future of these licence conditions, including the question of the stronger enforcement of benchmarks, is currently under review.

The NSW electricity grid

Long-term investment by the NSW Government has created one of the strongest and most extensive grid networks in Australia. This offers advantages for 'distributed generation projects' such as wind farms.

The NSW electrical transmission system, or 'the grid', is designed to distribute power from eight very large generators to millions of power consumers, of all sizes, spread across the state. Around 80 per cent of the power generated is used by customers in the Sydney, Newcastle and Wollongong regions. Consequently seven coal-fired generators are clustered around Sydney: on the Central Coast, in the Hunter Valley and near Lithgow, while the Snowy Mountains hydroelectric scheme is located south of Canberra. The map on page 42 shows the general structure and extent of the NSW high voltage transmission system.

The transmission system in NSW faces challenges presented by growing loads, the development of regional areas, changing market dynamics and 'through-traffic' from electrical interconnectors to Queensland and Victoria. To maintain quality of supply in the face of these challenges, options include upgrading the system, installing local distributed generation, or introducing demand management strategies.

Increasing attention is being given to distributed generation and demand management options as these can offer cost savings and environmental benefits. Regulatory and market drivers are being reviewed and developed to ensure that these less conventional options are considered and implemented where appropriate. This should assist the viability of wind energy projects in areas where system constraints are expected.

Transgrid, the NSW network service provider, holds public planning forums each year where it releases its Annual Planning Statement and discusses load forecasts, network constraints and development options. See **www.tg.nsw.gov.au**

Picture courtesy of Eraring Energy

Commercial issues for developers

How much does wind energy cost?

The cost per unit of electricity generated from wind turbines is determined by the total lifetime cost of building and operating the wind farm, and the total amount of energy it generates. Currently, the cost of generating electricity from large commercial wind farms in NSW is estimated at between 7 cents and 10 cents per kilowatt hour.

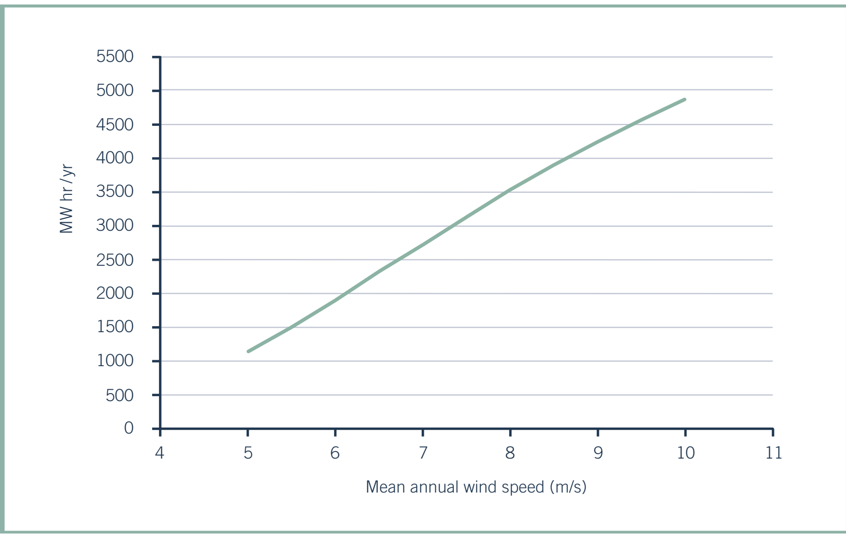
Wind farm costs: An approximate rule of thumb is that wind farms in NSW currently cost around $1.8 million for every megawatt of installed power. This includes the project development costs, the cost of the turbines and equipment, plus all installation and connection to the grid. The relative costs of the items in a typical small wind farm are indicated in the table below. Data is not readily available for the operation and maintenance costs of Australian projects, but it could be expected that these would add up to around $25,000 per year per turbine. Other factors would include the cost of financing the project and decommissioning the farm at the end of its life.

Element	% of total cost
Project development Site prospecting and selection Monitoring Feasibility Option agreement Environmental impact studies Community consultation Development approvals	5%
Wind turbines Nacelle, rotor, controls, switchgear Turbine tower Spares, consumables & tooling PC and phone line for remote monitoring	70%
Civil works Geotechical report and civil engineering design Other: hardstandings, roads, set-up etc	5%
Turbine installation Crane hire Specialist turbine installation crew Local labour	5%
Grid connection Extension of transmission lines to site Grid connection by network provider Transformer Switchgear and meter	10%
Other Project management Technical due diligence (noise, electricals, etc) Legal and financial fees Bank fees Insurance Contingency	5%
Total	100%

Approximate breakdown of costs in a 10–20 MW wind farm project

Energy yield: The amount of electricity generated by a wind farm during its life is basically determined by the amount of energy in the wind at the site and the ability of the wind turbines to convert that energy into electricity.

The wind speed at a site is the most significant factor influencing the amount of available energy, and the amount of electricity a wind farm can generate from this energy is determined by the total capacity of the wind turbines installed, their performance characteristics in the wind conditions, and the amount of time they are operating. The graph below illustrates how energy yield varies with wind speed by approximating the amount of electricity generated in a year by a 1 MW wind turbine in a typical NSW site for a range of annual average wind speeds.



source: CSIRO Wind Energy Resource Unit

Energy yield and wind speed

Support from SEDA

The Sustainable Energy Development Authority (SEDA) runs a number of initiatives to encourage the development of renewable energy supply in NSW, using methods such as investment in new commercial technologies, increasing consumer demand, stakeholder communication and education. See **www.seda.nsw.gov.au**

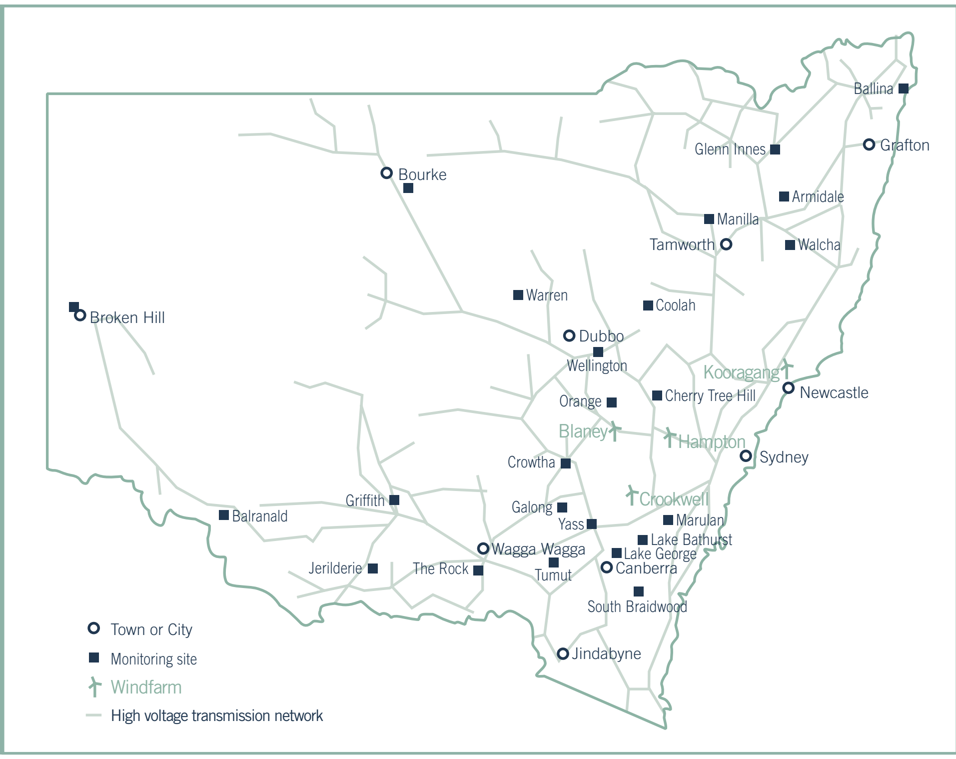
SEDA has a strong commitment to maximising wind energy development. Initiatives include:

- the NSW wind monitoring program;
- project development assistance;
- financial support and export assistance;
- liaison with other state and federal government agencies.

These initiatives complement each other to establish a world-best wind energy support system.

NSW wind monitoring program

The wind energy resource in NSW has been monitored for more than 20 years by a number of parties. However, this monitoring has been concentrated in a small number of sites, and the data is not publicly available.



Monitoring sites in NSW

Recognising that developers and others need access to high-quality wind data, SEDA has established a program which will monitor and map the wind energy resources in NSW. The main aim is to encourage the development of wind energy in NSW by avoiding lengthy, expensive wind prospecting exercises.

Data for SEDA's program is gathered from an initial network of 25 monitoring masts at sites across the state (see the figure opposite), which will be monitored for at least two years. SEDA has also accessed some of the data already available in NSW, and is generating an atlas of the state's wind energy resource using data from its monitoring program and other sources.

SEDA wind development services

SEDA also provides a range of modelling services based on the data acquired through the monitoring program. A network of highly skilled contractors is used in identifying potential sites, feasibility studies, business planning, planning approvals, and retailer relationship management.

Financial assistance

A growing pool of private and public capital is available from investment funds seeking renewable energy investments in NSW. SEDA has contact with a network of venture capitalists and investment banks interested in wind energy developments.

SEDA supports new renewable energy projects through the **Renewables Investment Program (RIP)**. This program promotes electricity generation, biogas production or fuel substitution based on renewable energy resources. It focuses on developing and demonstrating new technologies or new applications of existing technologies. It is not intended to support research and development activities, but demonstration projects involving new commercially sound technologies are eligible. Wind energy developments are a key target of the program. The RIP is offered in two rounds each year with up to $2 million available in each round.

Development partnerships: SEDA aims to accelerate the development of the NSW wind resource by working with developers and communities to help identify potential sites, investigate project feasibility, establish relationships with stakeholders, and facilitate viable projects. SEDA maintains a confidential database of landholders interested in further investigating the wind energy potential of their properties. SEDA also has close contact with developers and service providers in the industry who can make potential projects become reality. Contact SEDA on 9249 6100 for more information on development partnerships.

Export assistance

SEDA can help manufacturers arrange export from a NSW base. SEDA's 'Australian Sustainable Energy Gateway' actively promotes the Australian sustainable energy industry internationally. Favourable exchange rates and lower transport costs enhance existing opportunities in Asia and the Pacific. The gateway operates in conjunction with Austrade and the Federal Department of Industry, Science and Resources. See **www.asegateway.com**

Coordinating other government assistance

SEDA has close relationships with other state and federal government departments to help coordinate assistance and funding for research and development, manufacturing, and planning approvals.

The **NSW Department of State and Regional Development (DSRD)** promotes NSW as one of Asia Pacific's most competitive investment locations for international and domestic investors. DSRD provides consultative services to companies looking to invest into NSW. Services include providing economic data, tailored investment facilitation, and advocacy on a range of issues including planning approval processes and infrastructure. See **www.srd.nsw.gov.au**

The **NSW Department of Urban Affairs and Planning (DUAP)** administers the legal and administrative structure for land use regulation and environmental planning, under the framework of the Environmental Planning & Assessment Act 1979 (NSW). DUAP oversees strategic planning and gazettes state, regional and local plans, and is the consent authority in certain circumstances, such as state-significant development. It establishes standards for environmental impact assessment in NSW. See **www.duap.nsw.gov.au**

The **Australian Greenhouse Office (AGO)** is a federal agency within Environment Australia, which manages the Commonwealth Government's climate change response. It is responsible for coordinating domestic climate change policy and delivering Commonwealth programs. The AGO's Sustainable Energy Group offers funding programs which may support wind energy developments, including the Greenhouse Gas Abatement Program (GGAP) and the Renewable Energy Commercialisation Program (RECP). See **www.greenhouse.gov.au**

Picture courtesy of Eraring Energy

The Federal **Department of Industry, Science and Resources (DISR)** administers programs that increase the international competitiveness of Australian manufacturing, resources and service industries, and develop Australia's science and technology capabilities and infrastructure. See **www.isr.gov.au**. AusIndustry is DISR's agency for delivering information, programs and services which support industry, research and innovation; it offers research and development funding through R & D Start. See **www.ausindustry.gov.au**

Industry bodies

SEDA works closely with these industry bodies, all of whom support wind energy development:

Australian Wind Energy Association (AusWEA) **www.auswea.com.au**

Sustainable Energy Industry Association (SEIA) **www.seia.com.au**

Australian EcoGeneration Association (AEA) **www.ecogeneration.com.au**

Renewable Energy Generators of Australia (REGA) **www.rega.com.au**

4

Developing a Wind Farm

4

Developing a wind farm

> > This section describes the major considerations in the life of a wind farm development, from choosing a suitable site through construction and operation to decommissioning. Possible adverse impacts can be avoided with careful site selection, planning and design.

Step by step with minimum impact

Wind energy projects can comprise a single turbine primarily serving a small community, or they may be developed as larger 'wind farms' with connections to the national grid. There is no set size for a wind farm: the scale usually depends on economics, available land and transmission capacity. Established wind farms in NSW consist of between one and 15 turbines. Larger projects are common overseas and are likely to be developed in NSW.

This section provides an overview of some of the major considerations during the life of a wind farm. The AusWEA Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia identifies and describes in detail the seven stages in a wind farm's evolution and should be consulted for further detail. See **www.auswea.com.au**

The figure on page 50 shows a generic process for developing a wind farm, describing the considerations and activities relevant during each phase.

The seven phases for project development outlined by AusWEA are:

1. **Site selection:** A chosen area is assessed to identify one or more sites that may be suitable for development, identifying technical, commercial or environmental constraints.
2. **Project feasibility:** A single site is assessed in more detail, considering detailed wind assessment, design and layout options, grid connections and environmental impact assessment (EIA) requirements.
3. **Detailed assessment:** Once an individual site is shown to be environmentally and commercially viable, a more detailed assessment is undertaken and EIA commences.
4. **Planning application:** The developer submits a planning application to the planning authority.
5. **Construction:** The wind farm is built, with particular consideration of environmental impacts.
6. **Operation:** The responsibility of the developer for the satisfactory operation of the wind farm continues throughout its lifetime. There should be no significant environmental impacts if the wind farm has been appropriately sited and designed.
7. **Decommissioning:** Wind farms can be decommissioned easily and rapidly, returning the site to its original condition. Consideration should be given to ensure adequate funds are available to finance the decommissioning.

Steps in the Development of a Wind Farm

AusWEA Stages	NSW Wind Energy Handbook Discussion			
	Wind monitoring	**Duration**	**Discussion**	**Managing impacts**
1. Site selection 2. Project feasibility	Wind monitoring (minimum 1 year) (see Wind monitoring pg 54)	3-9 months	includes: - analysis of wind resource - analysis of technical and commercial factors - assessment of environmental and cultural factors - option agreement with landholder (see Site selection issues pg 51)	Managing impacts (life of the farm) (See Appendix B pg 76)
3. Detailed assessment 4. Planning application		4 months to 1 year	includes: - final design and layout (see Planning and design, page 53) - environmental impact assessment (see page 63) - planning approvals process (see page 61) - community and stakeholder consultation (see page 65) - lease agreement	
5. Construction		3-6 months	See Construction pg 53	
6. Operation		up to 20 years	See Commissioning and Operation pg 54	
7. Decommissioning		6 months		

Times indicated are suggested only, and vary according to project conditions.

4

Impacts

There is now enough known about the operation of wind farms, both in NSW and internationally, to make some generalisations about actual and potential impacts, although there will always be further site-specific factors.

The nature and extent of the local impacts of wind energy development depend on:

> the technology involved;

> the site and its specific characteristics;

> the nature of surrounding activities; and

> the appropriateness of site selection and effectiveness of the design.

A discussion of all actual and potential impacts of wind farms is presented in Appendix B (page 76). These impacts are considered in site selection and development applications.

Site selection

The first stage in planning a wind energy development is the initial selection of the site. A rigorous site selection process is critical to ensure that the proposed development is both financially successful and environmentally sustainable.

Initial dialogue with planning authorities will clarify potential issues that need to be addressed. The AusWEA Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia outlines a comprehensive site selection procedure.

The main **technical and commercial factors** which influence the selection of suitable sites for wind farm developments are:

° good wind resource – high average wind speeds, consistent wind throughout the year, low turbulence levels, minimal wind shading in prevailing wind direction (see Wind monitoring box on page 54);

° suitable topography – enough level ground to enable the installation of the planned number of turbines, and a topography which maximises windflow;

° proximity to transmission lines – within an economically viable distance of high-voltage transmission lines with adequate capacity for the planned development;

° zoning – permissibility under local development guidelines or environmental plans;

° good transport access – roads suitable for large trucks and cranes to deliver and erect wind turbines and equipment;

° proximity to customers – electricity companies generally prefer to buy power from wind farms close to their customer base to enhance the marketing benefits; and

- cost of mitigating local impacts – a range of potential local impacts can impose a cost on project development; appropriate site selection will minimise both the local impacts and the costs of mitigation.

Rigorous assessment of **environmental and cultural factors** at the site selection stage avoids these issues becoming adverse impacts during the operation of the wind farm. The main environmental and cultural factors which influence the selection of suitable sites for wind farm developments are:

- cultural appropriateness – considering Aboriginal site significance, heritage value, and other intrinsic values;
- community acceptance – the level of consent and support from the landholder, neighbours, local council and the wider community;
- compatibility with existing land use – land zoning allows wind farm development and existing use of land will not hinder the operation of a wind farm (and vice versa);
- environmental appropriateness – the point to which any adverse environmental effects arising from the wind farm's location can be managed;
- visual amenity – an assessment of the visual impact of the wind farm from key public and private viewpoints, using an objective visual impact assessment tool and photomontages;
- noise impact – the required distance between residences and the proposed development will depend on the local topography, the character and nature of local background noise;
- flora and fauna impacts – the potential impacts on local species of flora and fauna can be assessed through surveys of local species. For birds and bats this may require studies of flight paths and roosting areas etc.
- electromagnetic interference – the potential interference of TV and other communications can be determined through consultation with relevant bodies and on-site assessment.

Landholder relations

During the site selection process, an agreement between the developer and the landowner is established, whereby the landholder may be obliged within a certain period of time to enter into a long-term agreement with the developer for the purpose of wind farming. This allows the developer to investigate the feasibility of a site with the security that the site will be available if needed. The agreement may take one of a variety of forms, including a lease or site licence. In some cases the developer may purchase the property.

Once the site is selected, the developer negotiates an appropriate lease agreement with the landholder for the use of the land to operate the wind farm. The agreement will usually specify some type of lease payments, or else a royalty stream, for the life of the project. Lease payments can be calculated in various ways, including fixed annual payments per turbine and/or royalties based on energy yield.

Planning and design

Once an appropriate site has been selected a range of site-specific issues need to be considered. Planning and consultation issues are discussed in detail in section 5, page 61. Design issues include:

- Detailed site wind modelling. Using high-quality wind data, preferably from an on-site monitoring mast, and specialised modelling software, a numerical model is generated of wind behaviour on the site at a micro scale – say 25 metre intervals.
- Machine selection. Selecting the most appropriate wind turbine involves matching the characteristics of all commercially available machines with the specific project characteristics. Considerations include cost, wind characteristics, proven reliability, noise, visual amenity and impacts on the grid.
- Micrositing. The detailed turbine layout design will take into account many factors in addition to the location and strength of the wind resource, including noise and visual impacts, foundation engineering issues and ease of turbine erection. The exact layout will be a complex series of trade-offs, and there are several software tools which can aid in this process.

A wind-farm layout must take into account that turbines have substantial 'wakes', which interfere with each other depending on wind direction and spacing. The general rule of thumb for spacing (the '5r-8r rule') is five times rotor diameter abreast and eight times rotor diameter downwind. On very directional sites the 'abreast spacing' can be decreased by around 15 per cent, but the down-wind spacing is not as variable. Layout geometry can be primarily driven by the need to follow narrow ridgelines or to align arrays across the prevailing wind. On more complex terrain, individual sites need to be carefully evaluated to make best use of the wind resource, so the spacing may be quite variable.

Consideration of visual impact is essential. Regular spacings tend to look very regimented, such as the regular grids or 'bed of nails' layout of wind farms in the Altamont Pass in California. In Denmark, a coastal wind farm layout was designed by a landscape architect, who selected spacings with a random component to resemble scattered trees. A layout consisting of several turbines clustered or strung out on a ridge is now typical for wind farms in NSW.

Wind monitoring

Before a wind farm is proposed, there may be up to several years' data-collection and wind monitoring at the site, with measurement of wind speed and direction required at a range of different heights. SEDA can provide assistance with wind monitoring (see section 3, page 42).

Modelling techniques

The aim of wind monitoring is to estimate how much energy can be extracted from the wind for the life of a project. Long-term measurements (over one or more years) are best because the results must predict patterns for up to 30 years, including seasonal variation and long-term weather cycles.

In practice, wind farm developers are not willing to wait this long to gather information so, if good quality long-term wind data is available for a nearby site, statistical modelling can be used to take wind data over a shorter period and extrapolate into the future. The Bureau of Meteorology has long-term wind data available from a network of weather stations throughout Australia. This is not suitably accurate or detailed for wind energy predictions, but it can be used for prediction purposes.

Once data for wind speed and direction is obtained for a single mast, modelling software can estimate the wind behaviour for the surrounding area using topographic information. This technique is used within a 15 km radius of the monitoring point, because accuracy reduces further away from the monitoring point.

Wind resources can also be modelled from altitude weather data instead of ground measurements. These techniques are cheaper and faster than physical monitoring, but have limited accuracy. They are most useful in identifying areas with good wind potential. More advanced techniques are being developed by bodies such as the CSIRO, offering relatively high accuracy over large geographic areas.

Accuracy

Accurate measurement and analysis of a site's wind resource is extremely important. The wind resource at a site has a significant impact on the potential income from a wind farm and even small inaccuracies can lead to huge variations in actual income over the life of the project. Due to the physics of the wind energy, even a very small error in wind speed measurements can make a significant difference to estimates of the energy content in the wind. The use of accurate and credible data and analysis is particularly important for projects relying on funding from conservative investors and financial institutions.

Monitoring equipment

Research masts are installed at suitable representative locations to support anemometers and other measurement devices.

The masts are similar to those associated with long-term monitoring of wind farm areas. They may be between 30 and 100 metres high, and are fixed by guy wires. They are usually narrow (20 to 45 cm in width) and dark in colour, and so have minimal visual impact beyond their immediate vicinity. Tubular galvanised towers 10 to 15 cm in diameter may also be used. Because of their height, they may need a light if they are near an airport. No special access or maintenance provisions are required for research masts, although development approval may be required from the local council. Lattice towers may need to be metal-clad for the initial three metres to prevent people from climbing them.

An anemometer and wind vane are usually fitted to the mast at the hub height (height of the centre of wind turbine blades). Sometimes additional anemometers and wind vanes are also installed lower on the mast, to model characteristics such as wind shear (variation of wind speed with altitude) and turbulence more accurately.

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Anemometers typically consist of three cups, which capture wind and spin on a vertical axis. The rate of revolution of the cups and the direction of the wind vane are detected electronically and monitored by a data-logging device. These measurements are taken every few seconds and then averaged over 10-minute periods. Wind direction is measured using a wind vane.

Data loggers are usually capable of storing a number of weeks' worth of data at a time. Data can be downloaded either remotely, using a modem and telephone, or by collecting the memory chip or connecting to a portable computer. The data logger and communication devices are usually mounted in a weatherproof enclosure at the base of the monitoring mast, and power is typically sourced from a solar panel and battery.

Construction

The actual land area required for wind turbines themselves is small (generally about 1 per cent of the total land area of a wind farm). However, the construction phase will have effects over a wider area than that occupied by the infrastructure. Construction activity may also affect land use activities for short periods. Impacts mainly relate to restricted access to construction areas which may limit stock movement and interrupt cropping cycles. As some wind farms may be developed progressively over time, the construction phase may be staged or intermittent.

Site access: Construction of roads for site access may involve noise, dust and interference with watercourses and vegetation. Water management needs to be considered, and roads designed to avoid slips, minimise the removal of vegetation and avoid scars on the landscape. Any particular aspects such as ecologically sensitive areas or archaeological sites may also need to be avoided. Dust from access construction processes can be addressed by seeding temporarily stockpiled material, or occasional water spraying.

Access to and between turbines: Vehicles needing access to individual turbine locations include:

- vehicles for delivery of components, foundation construction and laying of underground cables;
- cranes for erection of the towers and turbine and blade installation; and
- cranes for commissioning checks, maintenance and repair.

Once turbines are installed, activities will involve small vehicles on an occasional basis.

Depending on the nature of the ground in the vicinity, access between installed turbines can be very low key. In some sensitive locations, revegetation may be very important, and access roads may be encouraged to become overgrown. In farming locations, pasture can be reinstated.

Dust: As wind farm locations are often windy exposed sites, there is potential for temporary dust nuisance during construction, and from excavated material left on site. One possible mitigation measure is to carefully spread this material, and plant or appropriately seed as soon as possible. Depending on the area, it may be desirable to import or collect water on site, to spray as a dust mitigation measure.

Ecology: If the construction phase is carefully addressed, major long-term effects on the ecology of an area are unlikely. Construction may be timed to avoid nesting periods for birds in the area, and to minimise erosion of exposed surfaces by rain or wind. Reinstating local ecology may require temporary fencing, and an active planting program.

Safety: As with any engineering project, the construction period involves some risks for site workers. This is an occupational health and safety issue, not a development issue. Public safety during the construction phase also needs to be considered. Temporary fencing and signs may be used to exclude the public from the construction site.

Noise: Noise may be caused by construction of access roads, excavation and construction of foundations, erection of towers and turbines, and construction of any assorted buildings or structures such as transformers or switchyards. It is much the same as any construction noise. In general, noise from the construction of wind farms will be minor and temporary, and will have minimal impact, especially in rural areas. Sites close to dwellings or urban areas may require consideration.

Traffic: Construction traffic is similar to that associated with any construction site. There will be several particularly long loads per turbine, conventional trucks bringing materials and possibly removing soil, and workers' transport. Oversized loads may be timed to avoid peak traffic on local roads.

Temporary buildings and parking: During wind farm construction some temporary on-site workers' and storage facilities will probably be needed. This may include site sheds, portable toilets and storage sheds or containers. Temporary parking areas may need to be laid out for workers' vehicles, as part of site management. As these are temporary only, they will generally have minor visual and site disturbance effects.

Commissioning

Commissioning of turbines may take a few days or a week for an individual turbine. It is done immediately after installation, and usually involves manufacturers' and contractors' representatives undertaking a series of tests relating to tower, nacelle and blade stability, and performance. Environmental impacts such as noise monitoring may be part of the commission tests.

If studies and tests in the development process have been adequately undertaken, all environmental impacts arising at commission have been anticipated. Regardless, this is the stage where effects such as communications interference or unexpected noise are noticed, and a turbine owner may need to do remedial work on or off-site.

Operation

Wind farms are long-term projects with time horizons of more than 20 years.

Maintenance and monitoring: Turbines require predictable ongoing maintenance. Maintenance checks and any actual maintenance involve few vehicle movements. Maintenance is done in-situ with access for each turbine via the tower. It is rare that a nacelle is removed for maintenance; rather, a crane would be used to remove major equipment items for servicing or replacement.

Performance is monitored remotely by computer, with most turbines having an anemometer and wind vane mounted on the nacelle. Wind farms may also retain the original anemometer masts installed for initial site modelling.

Public viewing area: Initially, wind farms will generate interest within the local community and amongst tourists, and a public viewing area may be established to provide information. This may have a parking area, an information board with a shelter and waste facilities.

Future project development

Wind farms may be regarded as long-term land use activities, which, like other land uses, may undergo upgrades, maintenance and change, as time passes. At the end of the 20 to 30-year design life of a wind farm the turbines may either be re-conditioned, upgraded or decommissioned. Australia has little experience so far with wind farms which have reached the end of their design life, but a number of overseas projects have been upgraded before the end of their life to take advantage of improvements in technology. When a wind farm is decommissioned, all above-ground elements are removed and the site is restored to its original condition.

Safety

The operation of modern wind turbines poses extremely low risks to public safety. All wind farm equipment is designed and manufactured to international standards. Wind farm operation around the world enjoys an excellent safety record. This is demonstrated in NSW by the wind turbine at Kooragang island in Newcastle, which has public access up to the base of the turbine.

The most significant hazards of a wind turbine to the public are also very rare. For example, the risk of blade detachment is extremely unlikely as wind turbines are designed with safety margins to account for the most extreme weather conditions. It is also highly unlikely that towers will collapse, as both foundations and towers are designed under strict quality assurance programs. The risk of components falling from the top of the tower is marginal as all components are enclosed in the nacelle.

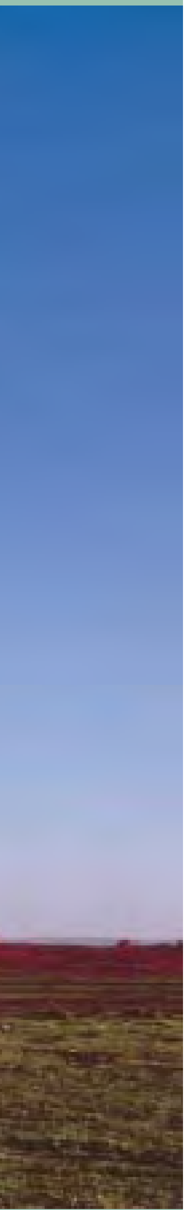
Operational risks to plant and personnel are controlled by adherence to safety systems such as site safety rules under the auspices of NSW occupational health and safety legislation, and electrical safety legislation. Access to the nacelle is fully enclosed by the tubular tower, and personnel must use safety harnesses at all times when ascending and descending the tower, or when working in or on the nacelle.

The design of modern towers also prevents unauthorised internal access to the wind turbine when the machine is unattended.

5

Planning issues for wind farms in NSW


Picture courtesy of Eraring Energy



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Planning issues for wind farms in NSW

> > This section outlines the process of obtaining planning approval for wind energy developments in NSW, and provides a practical guide to maximising the benefits of stakeholder and community consultation.

The planning approval process

The approval process varies from state to state. The NSW Department of Urban Affairs and Planning (DUAP) manages the planning system in NSW, and is the NSW land use regulator. DUAP administers the NSW Environmental Planning and Assessment Act 1979 (EP&A Act), which sets out the approval process for developments. The DUAP EIA Guideline for Wind Farms outlines a consistent approach to environmental impact assessment for wind energy developments in NSW. SEDA strongly recommends the use of this document. See **www.duap.nsw.gov.au**

However, most wind energy development proposals will be assessed by local council. The figure on the next page summarises the approval process for wind energy developments in NSW. The numbers on diagram are keyed to explanatory text in this section.

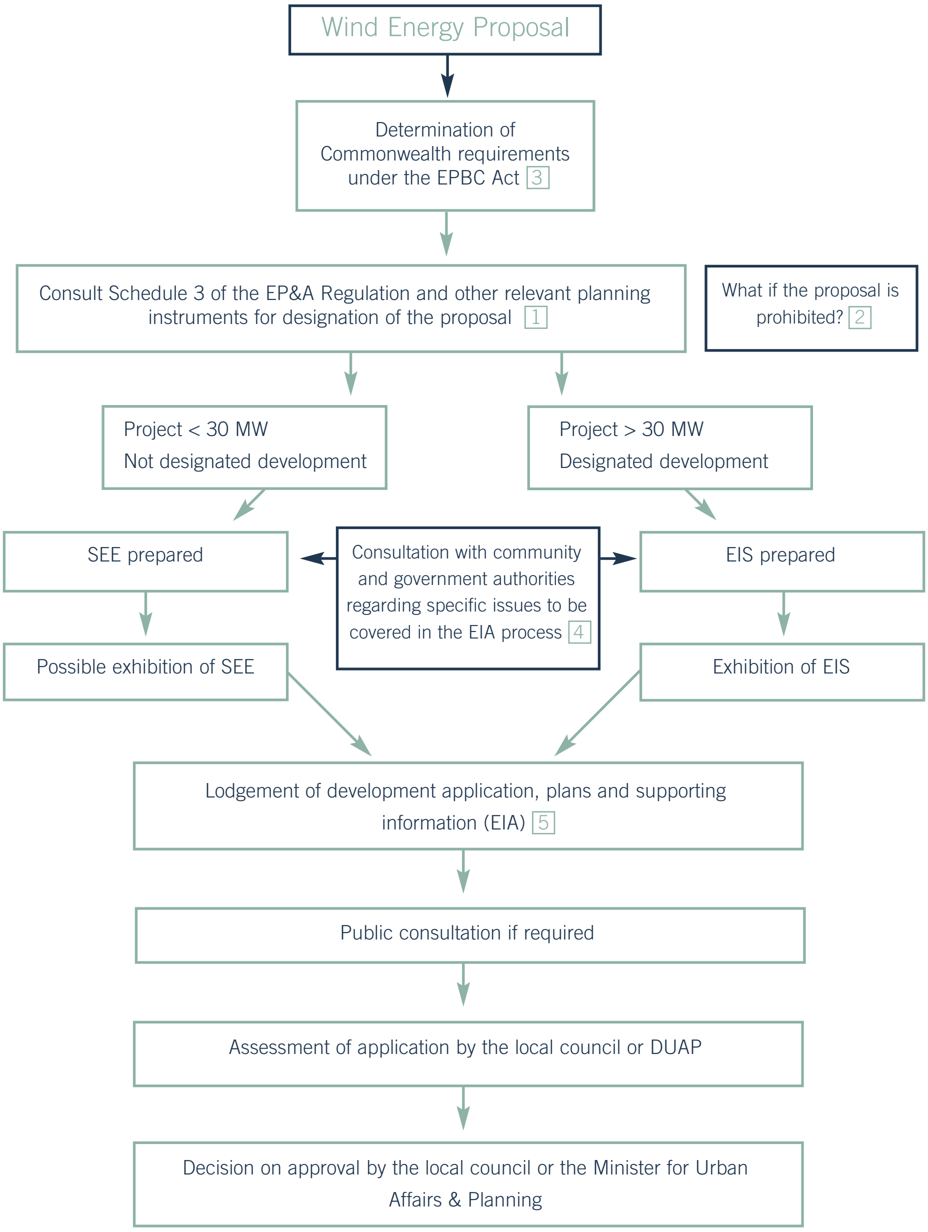
Is development consent required?

Consultation with the relevant local council will determine whether wind energy developments are permitted in the proposed location and whether development consent is required. The environmental planning instrument of the council, either a local environmental plan (LEP) or development control plan will contain this information.

To determine if development is permitted, and if so, whether development consent is required:

1. Determine the zoning provisions of the site(s) from the zoning map contained in the relevant zoning instrument.
2. Check the zoning document to determine whether the development is listed as prohibited, needing development consent or subject to any special requirements.
3. Check the relevant state environment planning policies (SEPPs) and regional environment plans (REPs) to determine if the development is specifically prohibited, if the requirement for council consent has been removed or if additional EIA requirements are imposed.

If a proposed wind energy scheme is permitted under the relevant planning instruments, an approval can be granted under either Part 4 or Part 5 of the EP&A Act. Part 4 'Development Assessment' applies where development consent is required and Part 5 'Environmental Assessment' applies where development consent is not required.



Glossary

Designated development: Particular types of development, which require an EIS to be submitted with the development application.

DUAP: NSW Department of Urban Affairs & Planning

EIA: Environmental impact assessment

EIS: Environmental impact statement

EPBC Act: *Environment Protection & Biodiversity Conservation Act 1999* (Cwlth)

Schedule 3: Schedule of the EP&A Regulation 2000, which designates particular types of developments.

SEE: Statement of environmental effects

nb. boxed numbers refer to text following

Simplified illustration of the NSW planning approvals process for a wind energy development under Part 4 of the EP&A Act

'Part 4' assessment of wind energy proposals 1

Part 4 of the EP&A Act applies to wind energy proposals or components of the proposal (such as transmission lines) that require development consent. If consent is required, proposals likely to significantly affect the environment may be 'designated' under Schedule 3 of the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) or under an environmental planning instrument.

Wind energy developments are included in the category of 'electricity generating stations', and are designated if the capacity is greater than 30 MW. In rare cases, other planning instruments such as a state policy or regional plan can designate a wind energy proposal.

Where a development is designated, an environmental impact statement (EIS) must be prepared and lodged with the development application (see Environmental impact assessment on page 65). If a wind energy development which requires development consent is designated, a statement of environmental effects (SEE) for the proposal must be submitted with the development application.

The local council is usually the consent authority for assessments under Part 4. The Minister for Urban Affairs and Planning may also be the consent authority for assessments under Part 4 where the proposal is of state or regional significance, or the Minister declares, by notice in the Gazette, that the proposal is a state-significant development.

'Part 5' assessment

The provisions of Part 5 of the EP&A Act are usually only relevant where a government authority is the development proponent. They apply when proposals do not require development consent and are not prohibited under an environmental planning instrument.

Under Part 5, a determining authority must consider whether the proposal has the potential to significantly affect the environment, prior to granting an approval or carrying out the project. If a determining authority considers significant impacts are likely, an EIS must be prepared and examined before an approval is granted. The DUAP guideline Is an EIS required**?** will help government authorities to decide if an EIS is required.

In some circumstances, some components of a proposal may require development consent under the provisions of an environmental planning instrument and fall under Part 4 of the Act, while other components may not require consent and fall under Part 5. In these circumstances, the provisions of both Part 4 and Part 5 apply, and the most appropriate way of preparing the proposal for assessment should be discussed with the Department of Urban Affairs and Planning.

What if the proposal prohibited? 2

If a proposal is prohibited, it cannot proceed unless:

1. It is an existing use.
2. It can be modified to be permissible through an environmental planning instrument.
3. The land can be rezoned.
4. It is a state-significant development i.e. it complies with the criteria for regional or state significance provided by the Minister for Urban Affairs and Planning.

The local council or the Department of Urban Affairs and Planning can provide further information about these options.

Other approvals

For some wind energy developments, there may be other approvals, in addition to development consent, which need to be obtained before commencing the project. Approvals may be required from other NSW Government authorities or from the Commonwealth Government.

Integrated development assessment

Integrated development assessment (IDA) will apply to wind energy developments that require development consent under Part 4 of the EP&A Act and one or more of a number of licences/approvals listed in Section 91 (1) of that Act. The state agencies responsible for granting these approvals are referred to as 'approval bodies' and include the Environment Protection Authority, National Parks and Wildlife Service, Department of Land and Water Conservation, Roads and Traffic Authority, Heritage Office and NSW Fisheries.

It is the responsibility of the developer undertaking the environmental impact assessment to determine which approvals will be required and to demonstrate that the proposal can meet all approval and licensing requirements. In preparing the EIA documentation, consultation with the relevant approval bodies should be undertaken early in the EIA process and any comments taken into account when finalising the details of the project. The list of organisations on page 69 includes potential approval bodies and others to approach for comment.

Commonwealth environmental approvals 3

Proposals likely to impact matters of 'national environmental significance' as defined under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) must be referred to Environment Australia to determine whether Commonwealth approval is required. This would apply to any action likely to have a significant impact on:

- nominated World Heritage areas;
- wetlands protected by the Ramsar Convention;
- nationally listed threatened species;
- nationally listed migratory species;
- all nuclear actions;
- the environment of Commonwealth marine areas;
- Commonwealth land.

An action that needs Commonwealth approval is called a 'controlled action', and an assessment report called a 'national environmental significance assessment' (NESA) must be prepared for all controlled actions.

The NSW environmental impact assessment (EIA) system is accredited under the 'assessments bilateral agreement' between the Commonwealth and state governments. This means the Commonwealth assessment process parallels the NSW EIA process and can be carried out along with the NSW environmental assessment.

Where the controlled action requires an environmental impact assessment or statement of environmental effects under the EP&A Act, the NESA could form part of that document. Environment Australia should be consulted regarding whether an action will be controlled, and if so, the advertising requirements and the contents of a national environmental significance assessment.

For more information about the EPBC Act and for a guideline on National Significance Criteria and for guidance on when proposals must be referred to Environment Australia, see **www.environment.gov.au/epbc**

Environmental impact assessment 4

Environmental impact assessment (EIA) is a major part of the decision-making process for gaining development approval. It investigates the potential effects of a proposed development or activity on the natural and human environment. EIA analyses how substantial the environmental impacts will be, identifies the safeguards or alternative approaches that can be taken to reduce or avoid potential adverse impacts, and determines the costs and benefits of a proposal.

Environmental impact assessment provides a link between planning, development and the environment and may be a very simple or highly complex process depending on the nature of the proposal and its impact on the environment. The assessment is the responsibility of the wind energy developer putting forward the proposal.

The environmental impact assessment process begins in the initial planning phases and is ongoing until the proposal is complete, that is, the wind energy development is built.

Part 4 and Part 5 of the EP&A Act, together with the EP&A Regulation 2000, specify the legal requirements for EIA. The Department of Urban Affairs and Planning's EIA Guideline for Wind Farms provides detailed guidance for the preparation of EIA documents.

For wind energy developments that are not designated (i.e. less than 30 MW) a **statement of environmental effects** will be the required EIA document. For wind energy developments that are designated (i.e. greater that than 30 MW, or designated under another environmental planning instrument) an **environmental impact statement** will be the required EIA document.

The DUAP **EIA Guideline for Wind Farms** are equally applicable to the preparation of an EIS or an SEE. A summary of the specific requirements for any assessment is listed in the table below, and these requirements are discussed in detail in the DUAP document.

All issues nominated will not have the same degree of relevance for all wind energy proposals. Depending on the characteristics of the proposal, some requirements may be more relevant than others, while others may not be applicable at all. In many instances, an SEE may not be as comprehensive as an EIS. In all circumstances, the EIA document should be tailored to the specific proposal and should focus on the key issues. The statutory requirements for an EIS are stated in Schedule 2 of the EP&A Regulation 2000.

In addition to the requirements in the DUAP Guideline, the project developer should consult the local council regarding any specific requirements for an SEE. If the Minister is the consent authority for an EIS, the Department of Urban Affairs and Planning must be consulted for Director-General's requirements.

If a proposal is on land that contains a 'critical habitat' or is likely to significantly affect threatened species, populations or ecological communities or their habitats, in accordance with the NSW Threatened Species Conservation Act, 1995 the Director-General of the National Parks and Wildlife Service should be consulted regarding the contents of a **species impact statement (SIS)**. The SIS will form part of the EIA documentation.

A. Executive summary
B. The proposal
  1. Objectives of the proposal
  2. Description of the proposed wind farm
  3. Site layout plans
  4. Construction issues
  5. Consideration of alternatives and justification for the preferred option
C. The location
  1. Planning context
  2. Site description and locality information
  3. Overview of the affected environment
D. Identification and prioritisation of issues
  1. Overview of the methodology
  2. Outcomes of the process
  3. List of approvals and licences
E. The environmental issues
  1. Greenhouse and energy issues
  2. Social issues
  3. Landscape and visual issues
  4. Noise issues
  5. Flora and fauna issues
  6. Heritage issues
  7. Telecommunications issues
  8. Waste issues
  9. Stormwater management issues
  10. Transport and traffic issues
  11. Water quality issues
  12. Soil and geological issues
  13. Air quality issues
  14. Economic issues
  15. Cumulative issues
F. Compilation of mitigation issues
G. Justification for the proposal

Specific requirements for an EIA as described by DUAP EIA Guideline for Wind Farms

Seeking development consent 5

Development applications with all supporting documentation are lodged either at the local council or, if the Minister is the consent authority (as a result of the EP&A Act or regulations or specified by an environmental planning instrument), at the Department of Urban Affairs and Planning.

An applicant who is dissatisfied with the determination of a consent authority may appeal to the Land and Environment Court within 12 months after the determination is made.

Community and stakeholder consultation

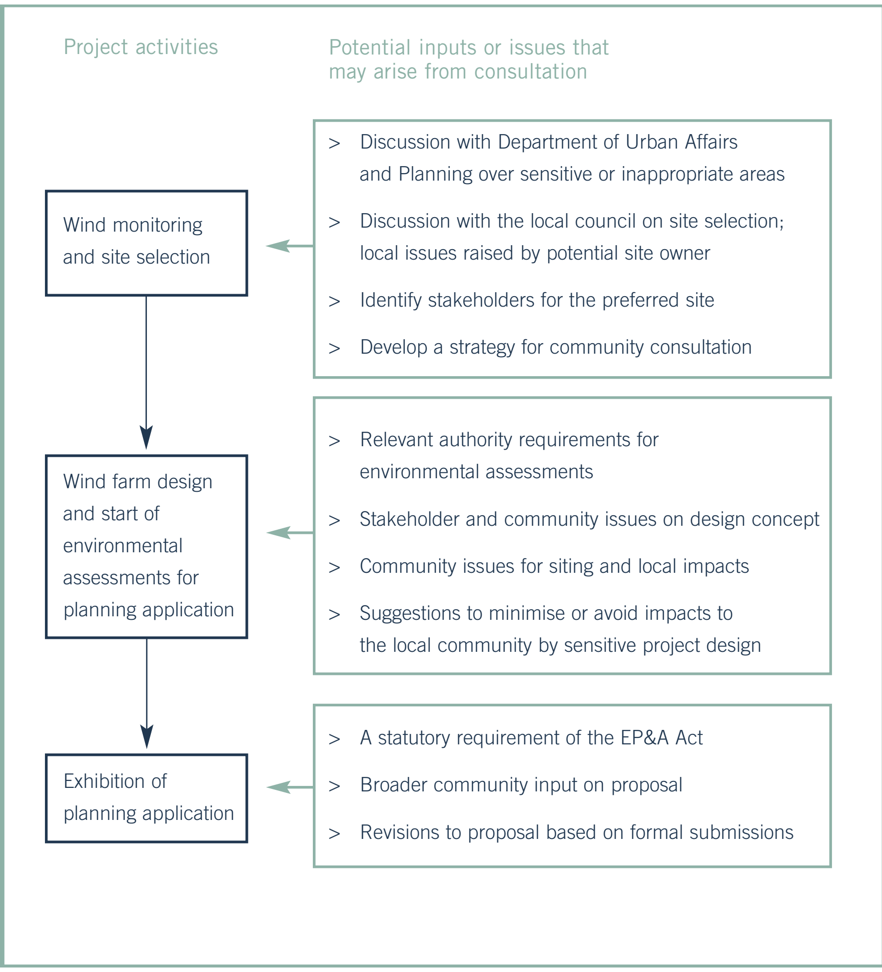
Consultation needs to be undertaken for proposed wind energy projects in NSW. This means seeking involvement from groups that are likely to be affected by the new development or that have some existing interest or statutory role in the project. Timely and appropriate consultation will add value to a project, through benefits such as:

- early identification of appropriate sites, ensuring development resources are committed effectively, and inappropriate sites do not proceed;
- avoiding project over-run by taking into account all authority requirements early in the process;
- enhancing local understanding of the development, its aims and its benefits;
- minimising impacts for local residents;
- improvements to the project, through sensitive siting and environmental management procedures;
- building community ‘ownership’ and pride in the development;
- DUAP EIA Guideline for Wind Farms outlines a minimum community consultation process for wind energy developments in NSW.

Approach to consultation

As a general rule, a developer should identify and actively seek out those who are stakeholders in a project, preferably during an early scoping phase, before project details have determined. The diagram on the following page shows how issues determined in consultation can feed into various stages of the project.

For most projects, there will be two levels of consultation, one for key stakeholders and another for the broader community. **Stakeholders** may be state and local government authorities, or community interest groups specific to the area. They will not necessarily be located adjacent to the site selected for a development. **Community** consultation will deal primarily with those residents surrounding the development, and in the neighbouring town.



The role of consultation at various stages of a wind energy project

Stakeholder consultation

Depending on the anticipated impact of the project, a developer may need to consult a number of authorities, as outlined in the NSW Environmental Planning and Assessment Act 1979, and the Environmental Planning and Assessment Regulation 2000. It is the developer's responsibility to determine what formal approvals are required, relevant to the level of assessment to be undertaken. The list opposite includes those groups that may be consulted during the project planning stages over technical issues. Not all groups will be relevant to every project.

5

Organisation	Consultation regarding	Notes
Local council	Local planning regulations (local environmental plans or development control plans) Location of heritage-listed items Development or building approvals	Discussion with the council should be undertaken during site selection process
Director-General of the Department of Urban Affairs and Planning	Requirements for carrying out an environmental impact assessment (EIS)	If an EIS is required, the proponent must formally seek the requirements of the Director-General of the Department of Urban Affairs and Planning
National Parks and Wildlife Service	Impacts to threatened species Location of sites of Aboriginal heritage significance	If a species impact statement is required the proponent must formally seek the requirements of the Director-General of National Parks and Wildlife
Environment Protection Authority	Environment Protection Licensing requirements, e.g. noise, waste generation, or runoff from construction	The EPA will issue licences under the Protection of the Environment Operations Act, once the project has been approved
Department of Land and Water Conservation	Issues regarding land clearing, or impacts to waterways	If relevant to proposal
Sydney Catchment Authority	Impact to Sydney drinking water requirements	If relevant to proposal
Roads and Traffic Authority	Changes to any roads or access ways	If relevant to proposal
Department of Aboriginal Affairs, local Aboriginal Land Council or local Aboriginal community	Issues relating to Aboriginal-owned land or site of Aboriginal heritage significance	If relevant to proposal
Service authorities (water, electricity telecommunication, sewerage)	If there will be any disruption to services	If relevant to proposal
NSW Agriculture	Any effects on local agricultural industry	Unlikely to be an issue
Heritage Council of Australia	State heritage items	Only required if proposal is likely to affect any items of state heritage significance
Environment Australia (Commonwealth Environmental Authority)	Matters of national significance	Approval will be required if Commonwealth land is involved in the proposal, or if the project contains matters of national significance
Department of Bushfire Services	Bushfire risk management	If the proposal is located in a bushfire hazard area

Possible stakeholders in a wind energy development proposal

As described earlier in this section, an environmental impact statement may not be required for wind energy developments under 30 MW, which reduces the legal obligation to gain approval from a number of state bodies. However, it is still worthwhile to consult with the identified stakeholders regardless of the level of assessment required.


Picture courtesy of Eraring Energy

Consultation can be in the form of individual meetings or letters requesting comment, depending on the stakeholder's level of interest in the project. One method of finding out about all the issues relevant to particular authorities is to hold a planning focus meeting where all stakeholder groups are invited to discuss the project. This is useful for major or potentially controversial projects, and should be held early in the planning process.

Community consultation

Community consultation has two steps, the first to provide information on the proposal and the second to seek some involvement in the development process. It aims to keep those who will be affected by the development fully informed about what's happening and give them a chance to have a say on some details of the project, where appropriate.

One very important element of the consultation for any kind of new development is to provide some point of contact for the community during development and construction. This allows people to ask questions or request information, and get a timely response from the developer.

A variety of cost-effective methods are available to gather community issues and build support for the project. A very extensive treatment of this subject is provided in the Department of Urban Affairs and Planning's *Ideas for Community Consultation* (2001). Other manual-style publications include *What We Need Is a Community Education Project* (Environment Protection Authority, and Department of Land and Water Conservation 1997) and the *RTA Community Involvement Practice Notes and Resource Manual* (Roads and Traffic Authority of NSW 1998).

A program of community consultation may be small and focussed on key residents or more widespread. Early discussions with the Department of Urban Affairs and Planning, SEDA, the local council, and the site landowner will help to determine a suitable program of activities. For very large developments, a program of consultation may need to be factored into the environmental assessment costs, and undertaken by specialists in the field.

The following list includes the kinds of activities that could be undertaken during the project assessment phase. The most appropriate activity will depend on many factors, such as the size of the community, their level of understanding of wind energy developments, their existing networks and their previous experiences with large development in the area.

Door-knocking: The project leader and other relevant team members approach individual neighbouring landowners to introduce the projects, discuss its aims, invite comments, and invite residents to be involved in the development process.

Seeking out existing community groups: In any community, existing groups often represent specific interests. If the local council has a community directory, this is a good starting point for seeking out groups to inform them of the project. Environmental groups in particular may be valuable supporters of wind farm projects. In rural areas key community groups may include:

- a local progress association, concerned with economic development of the town;
- a branch of Landcare or Bushcare, concerned with protecting native vegetation;
- members of Greenpeace, who actively campaign for wind energy in Australia;
- a branch of the NSW Farmers' Association;
- groups focussed on sustainability issues, such as permaculture and renewable energy.

Establishing a community liaison group: A group of community representatives can be formed to meet regularly during the assessment and possibly construction phase of the project to discuss project issues. Developers and landowners attend to hear community concerns and groups members are encouraged to distribute project information discussed to existing networks. The group may be formed by invitation or public notice.

Opening an information line: A telephone line provides a single point of contact within the development group for the duration of the project. A fax number for submissions, an email contact or a web site are other methods for providing community access to the project team. The contact points can be publicised through local advertising, newsletters, signage at the site, during media interview, etc.

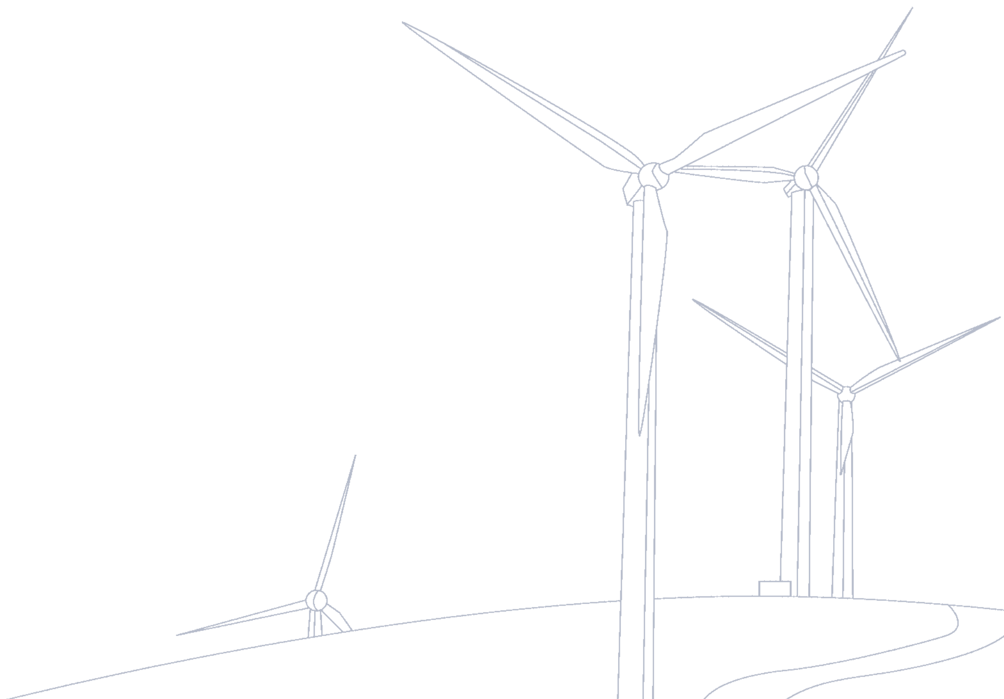
Setting up a project newsletter: A newsletter including information such as a project description, aims and timing can be delivered to homes and placed in public locations (for example, local council and library). A newsletter can be useful where there is a large neighbouring population, as it can reach a greater number of residents than doorknocking.

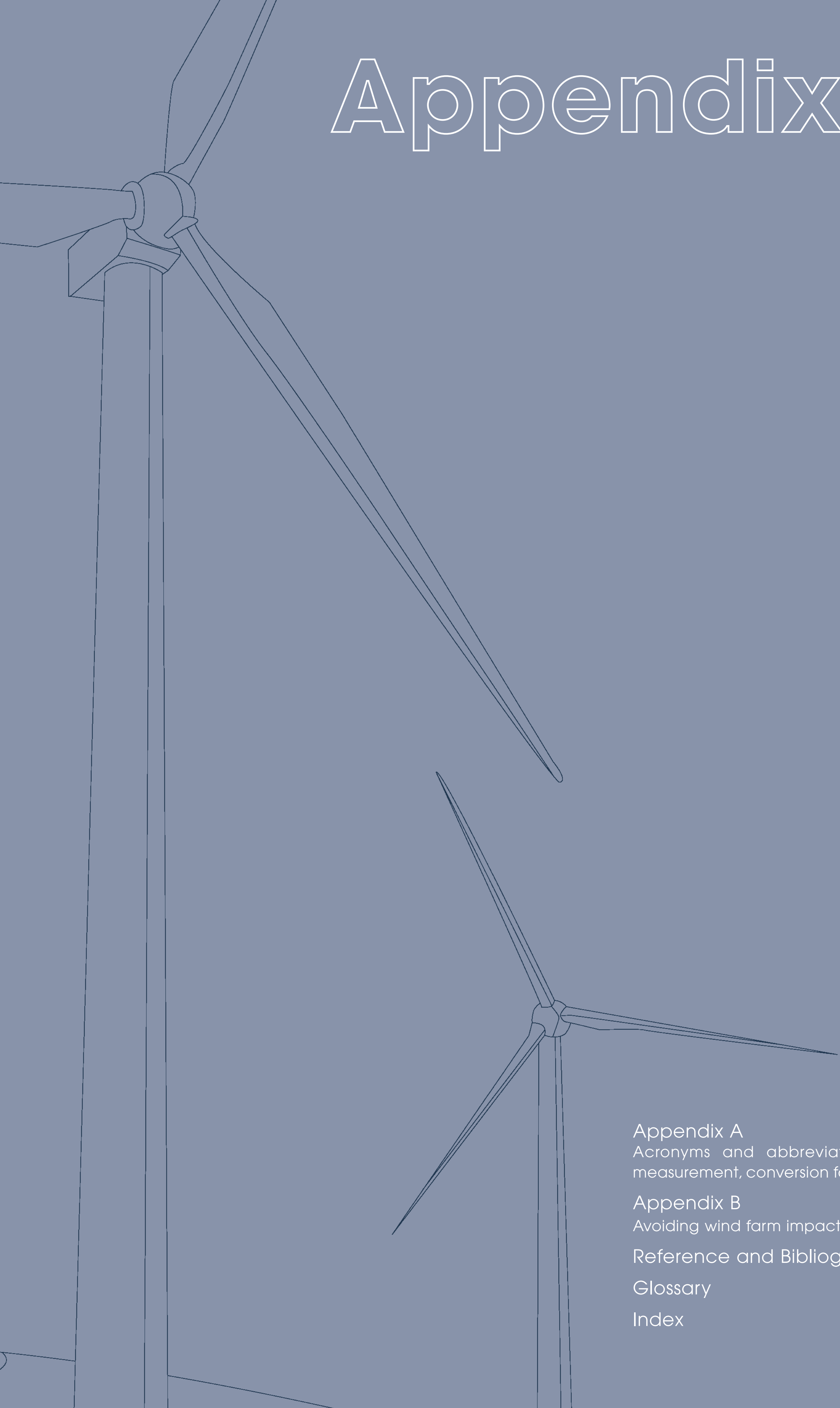
Advertising: Advertisements in the local paper can be used to call for public meetings, provide project updates, advertise public display dates and locations or request submissions on public documents.

Using public display stands: A simple stand with artists impressions, diagrams and photographs of similar wind farm developments can help to allay community fears about the project during the planning stages. Project team members staffing the display can directly answer any questions and take on board issues that are raised. Shopping centres, weekend markets or libraries are potential locations for a stand.

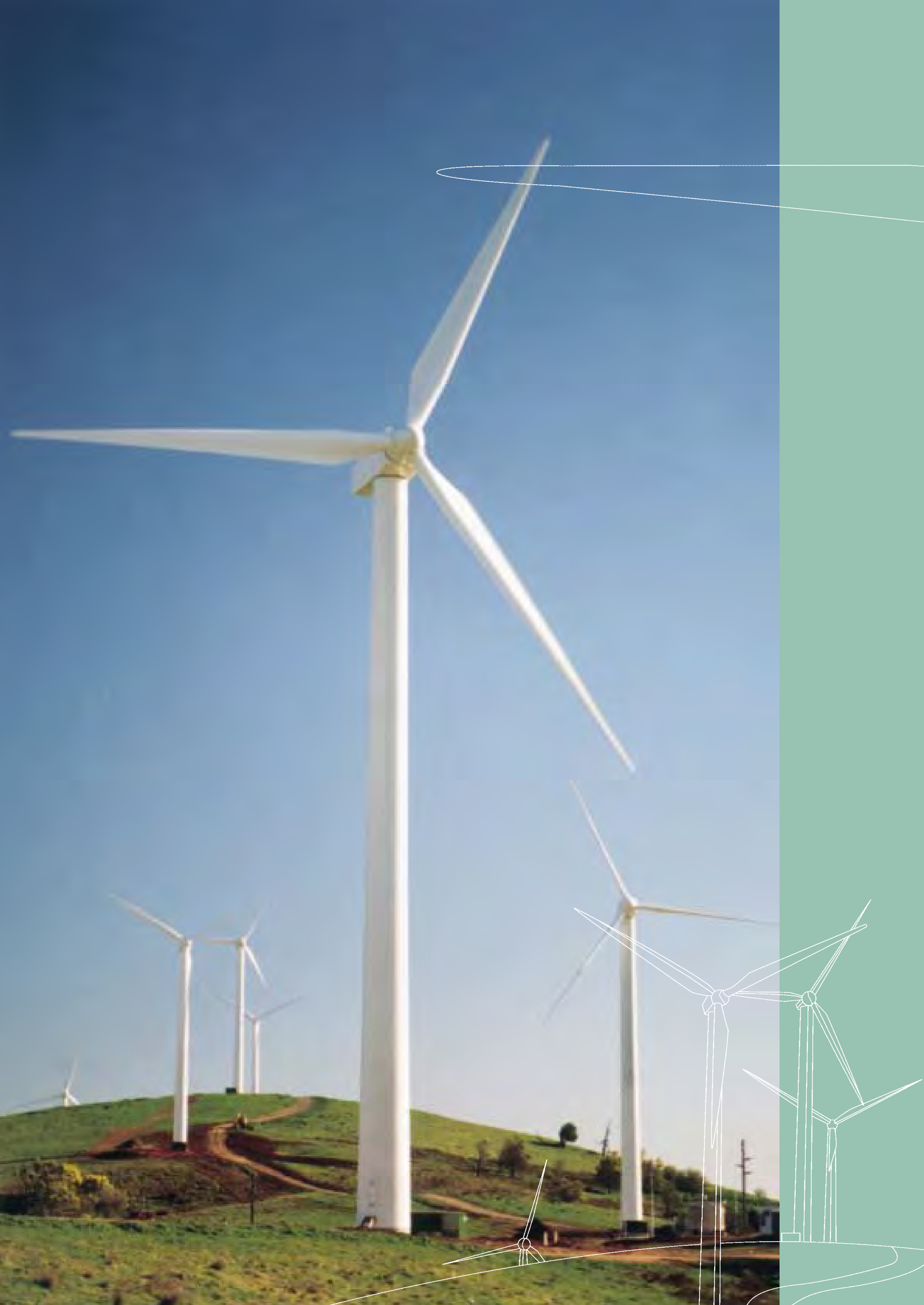
Issuing media releases: The local media can be notified when the site is chosen and the development process is made public. It can generate media stories and local interest. Once the story is in the media, it is important to make follow-up information available (for example newsletters, brochures) about the project, to communicate any complex issues that may arise.

Holding public meetings: A public meeting at the start of a project can be an effective way to inform interested members of the local community about the development. The disadvantages of this format are that it is difficult to enter into detailed discussion with a large group, and it is difficult to maintain an agenda. Smaller, focussed group meetings may be more productive to address community issues.





Appendixes



Appendix A

Acronyms and abbreviations

AC	Alternating Current
ACCC	Australian Competition and Consumer Commission
AGO	Australian Greenhouse Office
AusWEA	Australian Wind Energy Association
CASA	Civil Aviation Safety Authority
CO_2	carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DISR	Commonwealth Department of Industry Science and Resources
DLWC	NSW Department of Land and Water Conservation
DSRD	NSW Department of State and Regional Development
DUAP	NSW Department of Urban Affairs and Planning
EIA	environmental impact assessment
EIS	environmental impact statement
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
EPA	NSW Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)
ESAA	Electricity Supply Association of Australia
GHGs	greenhouse gases
GST	goods and services tax
HAWT	horizontal axis wind turbine
IEC	International Electrotechnical Commission
IPART	Independent Pricing and Regulatory Tribunal
LEPs	local environment plans
NECA	National Electricity Code Administrator
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company
NESA	national environmental significance assessment
NSP	network service provider
PPA	power purchase agreement
RAAF	Royal Australian Air Force
RECs	Renewable Energy Certificates
REGA	Renewable Energy Generators Association
REPs	regional environmental plans
RIP	Renewables Investment Program
SEDA	Sustainable Energy Development Authority of New South Wales
SEPPs	State environment planning policies
SIS	species impact statement
REPs	regional environment plans
PPA	power purchase agreement
SEE	statement of environmental effects
SIS	species impact statement
WTG	wind turbine generator

Units of measurement

m/s	metres per second
km/h	kilometres per hour
V	volts
kV	kilovolts
MHz	megahertz
W	watts
kW	kilowatts
MW	megawatts
GW	gigawatts
dB(A)	decibels
kWh	kilowatt hours
MWh	megawatt hours
GWh	gigawatt hours

Conversion factors

1 kilowatt (kW)	= 1000 W = 1.359 Horsepower
1 megawatt (MW)	= 1000 kW
1 gigawatt (GW)	= 1000 MW
1 m/s	= 3.6 km/h = 2.187 mph = 1.944 knots
1 knot	= 1 nautical mile per hour = 0.5144 m/s = 1.852 km/h = 1.125 mph
1 kilometre (km)	= 0.6214 miles

Glossary

abatement

Decrease or reduction. In the context of greenhouse gas emissions, a wind farm is said to 'abate' the greenhouse pollution which would otherwise have been emitted by conventional power generation.

anemometer

Instrument used for measuring wind speed and direction. Anemometers typically consist of three cups, which capture wind and spin on a vertical axis; and a wind vane which measures direction.

availability factor

The percentage of time per year that a machine is available to generate electricity, as opposed to the time that a machine is out of service due to maintenance or failure. Wind generation now enjoys excellent availability – typically over 99 per cent for the latest wind turbines.

capacity factor

The actual annual energy output of a generator divided by the theoretical maximum output.

commissioning

The final aspect of the construction phase. Manufacturers' and contractors' representatives undertake a series of tests and fine tuning relating to tower, nacelle and blade stability, and performance. Environmental impacts such as noise monitoring may be part of the commission tests.

decommissioning

The dismantling of a wind farm at the conclusion of its working life. The whole structure of the turbines and all related above ground infrastructure are removed, and the site landscaped to its original appearance.

distributed generation

Relatively small scale generation infrastructure (such as a wind farm) that is connected directly to the low voltage distribution network (also described as embedded generation).

flicker analysis

An analysis on the potential power fluctuations which a proposed wind farm may cause in the local grid to which it is connected. 'Flicker' refers to the effect on lights caused by fluctuations in grid voltage.

grid

The electricity transmission and distribution network.

hub

Attaches the rotor blades to the driveshaft in the gearbox/turbine.

hub height

The height of the centre of rotor blades.

load flow analysis

An analysis of the potential dynamic effect on the power transmission capacity of a section of the electrical grid.

mean annual wind speed

The average wind speed experienced at a site, at a given height, based on regular measurements throughout the year.

mitigate

To lessen in intensity or level.

nacelle

The structure on top of the tower that houses the gearbox and the generator.

network constraints

Limitations that will occur in those elements of the transmission and distribution network where the forecast load of electricity carried is approaching the designed capacity. These constraints can be addressed by upgrading the network, or the installation of distributed generation.

power factor

A measure of the efficiency of the grid system. A high power factor indicates higher transmission efficiency, which effectively reduces the total amount of power required from generators in the grid to supply a given customer load.

reactive power

A characteristic of power which can be used to increase the efficiency of the transmission of electricity, as measured by the 'power factor' of a system.

Renewable Energy Certificate (RECs)

The mechanism for accounting for the environmental attributes of electricity generated from renewable sources. One REC represents 1 MWh of renewable energy eligible under the Renewable Energy (Electricity) Act 2001 (Cwlth).

Glossary

transformer

A device which converts one voltage/current of electricity to a different voltage/current. A transformer at a wind farm steps up the voltage from 690V to the level to suit the distribution network.

transmission losses

Electricity losses that occur in the transmission and distribution network, often as heat.

turbine

A mechanical electrical generator.

turnkey project

A project in which a contractor completes an installation to the point of readiness for operation. Wind farms are frequently constructed in this way.

wind modelling

Manipulating raw wind data using software tools to develop an accurate understanding of wind resource in a particular location.

Picture courtesy of Eraring Energy

Appendix B

Mitigating wind farm impacts

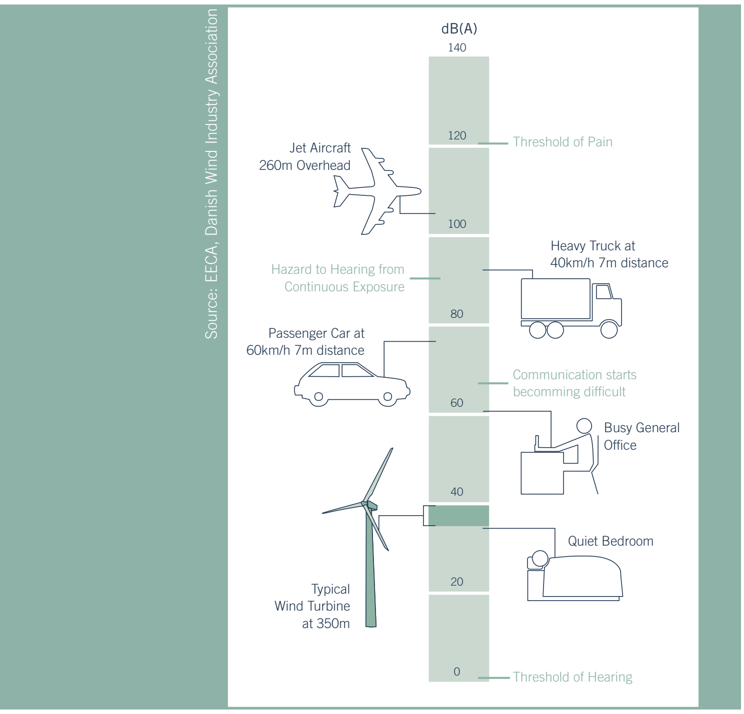
Impacts discussed here include noise, visual impacts, impacts on communications systems, impacts on birds and bats, other ecological impacts; social and cultural impacts, impacts on aviation, lightning, and public safety. These can be avoided or minimised through careful site selection, planning and design.

Noise

The total noise generated by a wind turbine is made up of several components, broadly grouped as mechanical and electrical noise, and aerodynamic noise. Noise is generated only when the turbine is operating. For most turbines, this is at wind speeds of between approximately 4 m/s and 30 m/s. The combination of noises from a wind turbine can be described as a mechanical noise such as a car running, combined with an aerodynamic pulsating sound from the blade movement.

In fact the lack of intrusion on daily impact has been graphically demonstrated at the Crookwell wind farm, where a permanent dwelling has been built on open ground since the wind farm, well within 400 metres of the nearest turbine.

There is no standard method for assessing noise from wind farms in NSW. Some developers have used the New Zealand Standard NZS 6808:1998 Acoustics - The Assessment and Measurement of Noise from Wind Turbine Generators.



Relative noise levels

Background noise

Background noise is not constant, but varies with wind speed, weather and noise-producing activities. The component of background noise due to wind increases with increasing wind speed.

Mechanical and electrical noise

Mechanical noise originates from sources such as the gearbox, cooling fans, electrical generator and transformers. Occasional low-level mechanical noise can arise from motors that control the pitch of the blades and the orientation of the nacelle. All mechanical noise sources are contained within the nacelle. A variety of techniques are used to reduce these noise sources. These include the use of specially designed gears and mountings for vibrating components, and the use of acoustic insulation to dampen noise. Wind turbines are designed to reduce mechanical noise to such levels that the dominant noise from the turbine is the aerodynamic noise.

The electrical generator, transformers and power electronics can emit electrical noise. These sounds are usually tonal, and have been minimised so they are inaudible except in very close range of the turbine.

Aerodynamic noise

The action of the blades 'cutting' through the air causes most of the noise from a turbine. This 'aerodynamic' noise is made up of wide range of frequencies.

Close to the turbine, the aerodynamic noise heard by an observer on the ground varies with the rotation of the blades, increasing in volume each time a blade passes the tower. At a distance, and when turbines are grouped together in a wind farm, this variation is less noticeable and the noise blends in with local background noise.

Effect of wind speed

Wind turbines only produce significant noise when they are generating electricity. When wind speed is less than the 'cut-in' speed of the turbine, the turbine is either stationary or turning slowly, and is not generating electricity. Above the 'cut-in' speed, the turbine will rotate and generate electricity, together with some noise. The amount of noise increases as wind speed increases. However, the background noise created by the wind increases at a faster rate than the noise created by the turbine. So the noise from the turbine will be most noticeable at low speeds. At higher wind speeds (above 10 m/s), the noise of the wind itself normally masks the turbine noise.

Noise attenuation

Sound levels decrease (attenuate) with increased distance from the source. The simplest approximation is that noise levels reduce to a quarter of the energy for each doubling of distance from the source. This is due to the hemispherical spreading of sound from a point source.

A barrier between the sound source and the observer reduces sound levels. The amount of attenuation cannot be precisely defined because it depends on frequency. Typical figures for broadband noise are an 8-12 dB(A) decrease for locations not in the line of sight of the noise source, and further 10 dB(A) decrease inside a typical residence with open windows. With windows closed the decrease is 20 dB(A) or more, depending on glazing.

Noise decreases rapidly with distance. Noise from a turbine which typically emits 95-105dB(A) at source will reduce to 55-60dB(A) at a distance of one rotor diameter from the tower base, and will be virtually indistinguishable from background levels of 35-45dB(A) at 350m distance.

Noise measurement

There is no Australian noise standard for wind turbines. New Zealand Standard NZS 6808:1998 Acoustics - The Assessment and Measurement of Sound from Wind Turbine Generators may be useful as a reference. The standard suggests that the predicted sound level from a wind farm should not exceed the ambient level at a residential site by more than 5 dB(A), or an absolute level of 40 dB(A), whichever is greater.

Manufacturer's specifications

The noise of a wind turbine generator can be determined from a manufacturer's standard specification, and the noise generated should not vary over time. Aerodynamic noise is also often estimated in a manufacturer's specification. This information can be compared with available measured information relating to background noise of the local environment.

Special cases

Wind turbine developments which are located close to dwellings, or which have particular audible characteristics, may require further evaluation. Similarly, the nature of the local terrain, its vegetation cover, and any specific characteristics of the local wind conditions (such as frequent low wind speeds in a valley floor in combination with high wind speeds on top of a nearby hill) can modify noise levels. Particular prevailing winds may result in higher than normal noise levels for some neighbours, and this also needs to be taken into account.

Visual impacts

Visual impact is one of the most problematic aspects of wind energy development. People's responses to turbines vary widely – they can be perceived as 'dynamic visual sculptures' by some, and as an unacceptable visual intrusion by others. Responses may also change over time and with experience. For example, a Scottish study found that local residents were more receptive to wind turbines after a wind farm had been operating for some time (see Public attitudes to wind farms in section 1, page 13).

The easiest way to address visual impact is to avoid locations where turbines are seen by many people. However, in wilderness areas, the intrusion of wind generation developments can be visually unacceptable because of their industrial associations. Wind farm developments are often likely to be located close to settlements, and seen by people, so visual aspects need to be considered.

Site location, size, tower design, colour, wind turbine layout and spacing are all important factors. Access roads, site buildings and any additional electricity transmission requirements may also require consideration in any specific development.

The visibility and the form and pattern of the existing landscape will largely influence the acceptability of any wind farm development. In NSW higher ridges are likely to be the most frequently sought locations for wind farms. Contours and, in agricultural areas, existing landscape features such as trees, hedges and roads, must be taken into account in any visual evaluation. Because of their size and shape, and the need for good 'wind runs', wind farms cannot be concealed behind planting, although planting close to an affected road, house or viewspot may conceal the turbines and reduce the visual effect in specific circumstances.

The following design techniques have been found to help minimise the visual impact of wind farms:

- all turbines should be a similar size and style;
- blades should always rotate in the same direction;
- if the site is flat, a regular layout along straight lines may be preferred to a random scatter of turbines;
- on sites with variable terrain a random scatter of turbines may be preferred;
- light colours – pearly grey and non-reflective white – have been found to be most appropriate for all parts of the turbines in Northern Europe, where they tend to be seen against a sky background. If the background is other than sky, darker colours may be appropriate;

- distance and scale of the landscape is a major consideration. In an open or grand landscape, wind farms can be of minor impact. However, the human eye is often drawn to 'artificial' vertical features, regardless of distance, making them seem bigger.

Each development will need to be considered on its merits in terms of site and locality-specific considerations such as distance, background, landscape scale and number of potential viewers.

Useful tools for evaluating visual impact include a plan showing areas from which a turbine or farm will be visible, and a photomontage of the potential development from one or more viewpoints.

In the UK, local authorities prefer to encourage clustering of wind farms in some areas, on the basis that other areas will remain free of them. On the other hand, some local authorities prefer dispersal. The cumulative effect of several wind farms visible from a single locality has been noted, but there is as yet no information as to how such cumulative effects may be assessed.

Site access roads may also have some visual impact. In some instances existing roads give adequate access. In others a new construction access is required, and this is retained as long-term maintenance and replacement access. The large and long loads associated with wind turbine construction require particular road geometry, which may not be totally sympathetic to the local topography, particularly in steep country.

The location and design of access roads, effects on vegetation, disposal of excavated material, and treatment of exposed faces, may all be evaluated in terms of the long-term effect on the landscape.

Similarly the visual impact of new transmission lines must be evaluated. If new transmission lines involve land disturbance, the visual impact of this must be considered.

Visual impacts from blade rotation

Other than through their general appearance, turbines can have visual effects such as shadow flicker or blade glint that can be a temporary nuisance. Manufacturers pay particular attention to these factors and the problem has largely been solved by use of suitable paints and the slower speeds of the rotors.

Shadow flicker or strobe effects can arise within houses if the turbine is located in a position where the blades pass across the sun, causing a flickering shadow within a room. This occurs only where a turbine is close to a dwelling, and at very low sun angles. It is unlikely to be an issue in NSW because the separation distance required for noise mitigation is usually more than enough to prevent shadow flickers.

Blade glint – the regular reflection of sun off rotating turbine blades – can be a temporary distraction to drivers if roads are aligned towards turbines. The effect can be noticed over considerable distances – as much as 10 to 15 km. Its occurrence depends on the orientation of the nacelle, the angle of the blade, and the angle of the sun. The reflectiveness of the blades is also a factor, influenced to some extent by their colour and age. Matt surface finishes are specified to minimise the effect.

Communications impacts

Radio, television and microwave transmission can potentially be affected in several ways by individual turbines and wind farms:

- the tower may obstruct, reflect or refract the electromagnetic waves used for transmission in a range of communications systems;
- the rotating blades can have similar effects: if they are made of metal, or have metallic cores, these can act as an aerial to 'on-transmit' the communication, which may cause, for example, ghosting in local TV receivers;
- the generator itself can produce electromagnetic interference, although this can usually be suppressed by shielding design and maintenance of turbines. In practice, a generator is little different from any other electrical machine, and only in rare circumstances is a wind turbine generator likely to be a potential problem.

These effects will be relatively limited, as the tower and blades are slim and curved, and consequently will disperse rather than obstruct or reflect electromagnetic waves. Most blades are made of a material that is transparent or absorbent to waves, minimising the risk of problems with communications.

The location, size and design of the turbines may be important, depending on the location and nature of the communication transmission facilities. In NSW, numerous communication systems use high points in the landscape, and it is inevitable that there will be some concern expressed by communications users such as cellular phone companies, local and national utilities, and emergency services such as ambulance and coastguard.

Generally, the communication systems most likely to be affected are those which operate at super high frequencies (particularly microwave systems operating at frequencies above 300 MHz). These rely on line of sight between transmitter and receiver. Any obstruction in the vicinity of a straight line between these two points may cause interference and signal degradation.

Ways can be found to mitigate, avoid or remedy all electromagnetic effects. This may include choice of specific location for a particular turbine, or choice of wind turbine generator type, tower design, or specific blade material. Shifting or enhancing existing communications installations may also be a possibility. A small shift in a line of sight radio path can make a large difference to whether the path is obstructed by the turbine or not.

For any proposed wind farm, the best way to identify and address potential adverse effects is for a developer to identify and consult with communications operators at an early stage. Normally the consultation process will identify concerns. Potential developers generally resolve issues through private agreements, before seeking approval to proceed.

Impacts on birds and bats

This aspect is discussed in overseas literature on wind farms. Two main problems have been noted overseas:

- In the USA many raptor (eagle family) deaths were associated with early wind farms because the farms were located in the high passes frequented by such birds. The cause of the deaths was most frequently electrocution on uninsulated transformer and transmission facilities associated with the wind farms, and is now avoided by better design.
- In Europe, a few wind farms are located on main migratory flight paths. Migrating birds, particularly larger and slower birds, have been found to be at high risk of flying into towers or blades.

Locally resident birds of most types appear to grow accustomed to the presence of local turbines, and have no difficulty avoiding them. Turbine blades have a maximum tip speed of approximately 50 to 100 m/s, and can be seen and avoided by most birds, including birds of prey and sea birds. Water birds and night feeding sea birds have been found to be at slightly greater risk than other birds. It's a hazard to individual birds rather than a threat to the species.

Numerous studies overseas have compared the bird deaths associated with wind farms with the effect of stretches of road, motorway or transmission lines, and have found wind turbine effects to be significantly less.

Due to the limited experience of wind farms in Australia, their potential impact on birds is not completely known. The risks are expected to be low, as migratory paths are rarely over land, and there are relatively few large-bodied flying birds. Bird and bat populations need to be explicitly considered in the environmental impact assessment process.

Other ecological issues

The main potential ecological impact is the possible disturbance of existing species and habitats during the construction phase. Wind farms frequently occupy agricultural land that has been disturbed by agricultural practices, and where ecology and habitats are already highly modified. It is unlikely that there will be any ecological concerns associated with development in such areas.

Where a wind turbine or a wind farm is to occupy non-agricultural land, it is appropriate to confirm that no representative, rare or endangered habitats or species will be affected. A field survey and a search of the National Parks and Wildlife Service database would be required to identify whether any threatened species are present in the vicinity.

As wind turbine foundations occupy only small areas of land (about one per cent of the total site), generally local ground habitat re-establishes quickly. Strategies to minimise the impact of construction activities could include avoiding key times of the year, such as nesting periods, or adjusting specific turbine locations to avoid plant specimens. Experience in Australia as well as Europe suggests that local species, including territorial birds and animals, readily re-establish in a wind farm locality.

Social and cultural impacts

Impacts on culturally significant sites: Indigenous people may have strong associations with particular landscape features. Consultation is important to ensure that wind farm developments are respectful of these associations. A search of the National Parks and Wildlife Service Aboriginal Sites Register and consultation with the local Aboriginal Land Council are suggested starting points to identify any culturally significant sites. See **www.upws.nsw.gov.au**

Impacts on the intrinsic values of areas: As well as cultural values associated with sites, people may have strong feelings about or associations with some areas. For example, areas may have wilderness or remoteness values, historic associations, or may contribute to the 'sense of place' for a nearby settlement. These values are often difficult to identify and define, but are 'intrinsic' to the area. Effects on intrinsic values are distinct from visual impacts. A community consultation process can help identify and address such values.

Archaeological and historic sites: Relatively little ground disturbance is associated with wind turbines or wind farms. However, the preferred wind farm locations, including land in coastal and ridge locations, may contain archaeological evidence or material. This is because of the importance of such areas in pre-European, and sometimes more recent, times.

The NSW Heritage Act 1977 covers all sites and artefacts that are more than 100 years old, and requires a procedure, including cessation of work if any evidence of an archaeological or historic site or any artefacts are found. It is preferable that appropriate records are inspected and a surface investigation carried out, if appropriate, prior to approvals being given. Opportunities to avoid or mitigate damage should be built into any proposal affecting an archaeological or historic site.

Impacts on other land uses: As wind farms affect the productivity of only a very small part of the land they occupy, they tend to have little effect on other land uses. Wind turbines can co-exist with many types of land use. Exceptions are urban development (particularly residential areas), forestry areas, and sensitive activities such as airports and some communications facilities.

Once a wind farm is established, its owner is likely to strongly discourage nearby planting of trees, or any other activity that may influence wind in the vicinity. One way to achieve a suitable buffer area free of trees may be for owners to enter into direct contracts with adjoining landowners.

Aviation impacts

Because of the height of the turbine tower and blades, if there is an airport in the vicinity, flight path envelopes must be avoided. The Civil Aviation Safety Authority (CASA) should be consulted about the need for warning lights on towers (lights on blades pose a particular problem due to their rotation). Reasonable separation from airports is preferable. It is a mandatory requirement of any development application to inform CASA of structures over 110 metres in height. The Royal Australian Air Force should also be consulted, as they are concerned about obstacles to low-flying planes. See **www.casa.gov.au** and **www.defence.gov.au/raaf**

Airstrips in rural areas are usually not protected by any designation or civil aviation requirements. If there are airstrips in the vicinity, potential developers may need to consult with owners and users to ensure that potential risks are avoided or mitigated.

Lightning

Wind turbines do not attract lightning more than any other vertical element in the landscape. Lightening arrestors built into the turbines mean no risk is posed.

Public safety

Most wind energy developments will not be on land available to the public, so public safety should not be an issue. However, it sometimes arises, for example if a public walkway coincides with a wind farm, or if the public are invited into the vicinity to view the working wind farm at close quarters.

All commercial wind turbines currently available in Australia meet international engineering design and manufacturing safety standards. This includes tower, blade and generator design. There is an international quality control assurance program for turbines, and a number of relevant standards.

In addition, foundation design and commissioning checks address potential failure due to extreme events such as earthquakes or extreme wind loadings, as well as frequency tuning of the different parts of the structure to avoid failure due to dynamic resonance.

International experience to date has indicated very low risks associated with tower collapse, components falling from towers, and blade throw. Risks appear to be reducing further as technology improves.

Other impacts

Specific developments may require special consideration of some aspects. For example, a public viewing area or education centre may involve additional buildings, access, traffic management and parking considerations, and higher levels of security for any switchyard, for example. All of these would need to be evaluated in terms of visual impacts, traffic generation, and public safety. The techniques to address these impacts are well understood, and suitable means of avoiding, remedying and mitigating them can be found.

Picture courtesy of Eraring Energy

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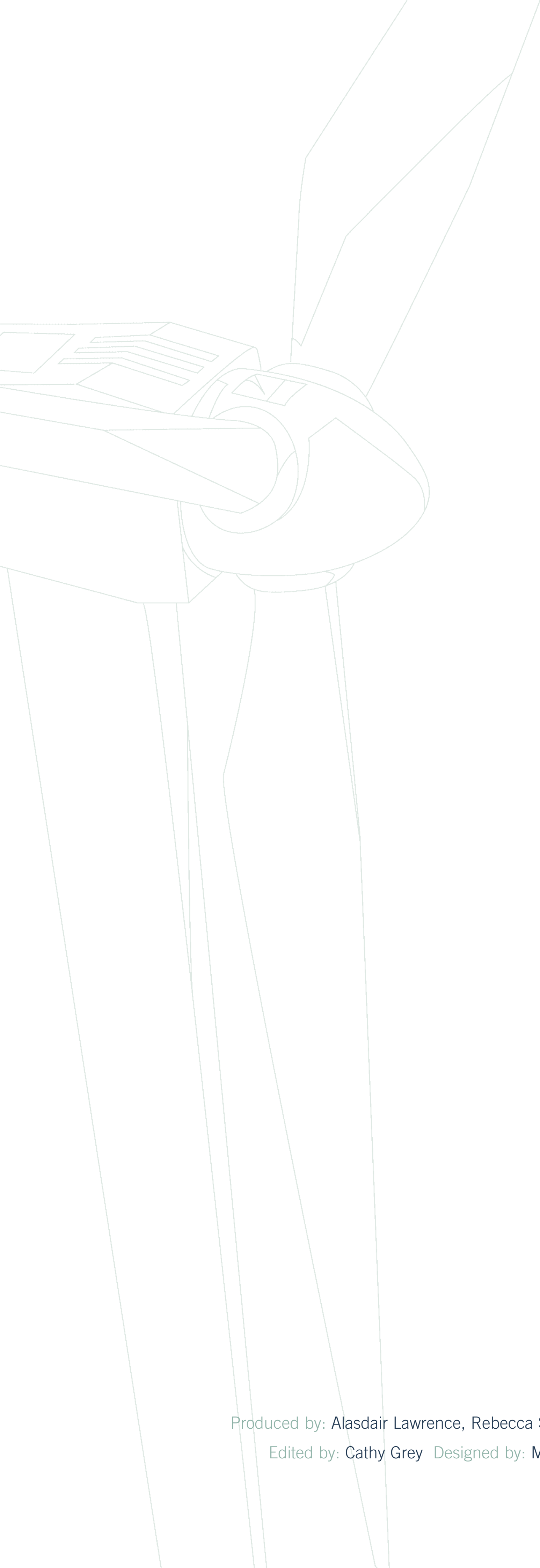

Produced by: Alasdair Lawrence, Rebecca Short & Andrew Williamson, SEDA
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