FACT SHEET 1

# Wind Farm Basics

## What Is A Wind Farm?

"Wind Farm" is the name used for any group of adjacent wind turbine generators that are connected electrically. This includes vehicle access tracks, underground cabling for electrical interconnection and communications, and the switchyard at the point of connection to the grid. In Australia, wind farms have been built with between 1 and 60 wind turbines.

Each wind turbine acts independently, generating from the available wind resource. The electricity flows through common cabling out into the grid. The turbines are usually arranged to maximise use of the wind available and placed sufficiently far apart to avoid interference with one another.

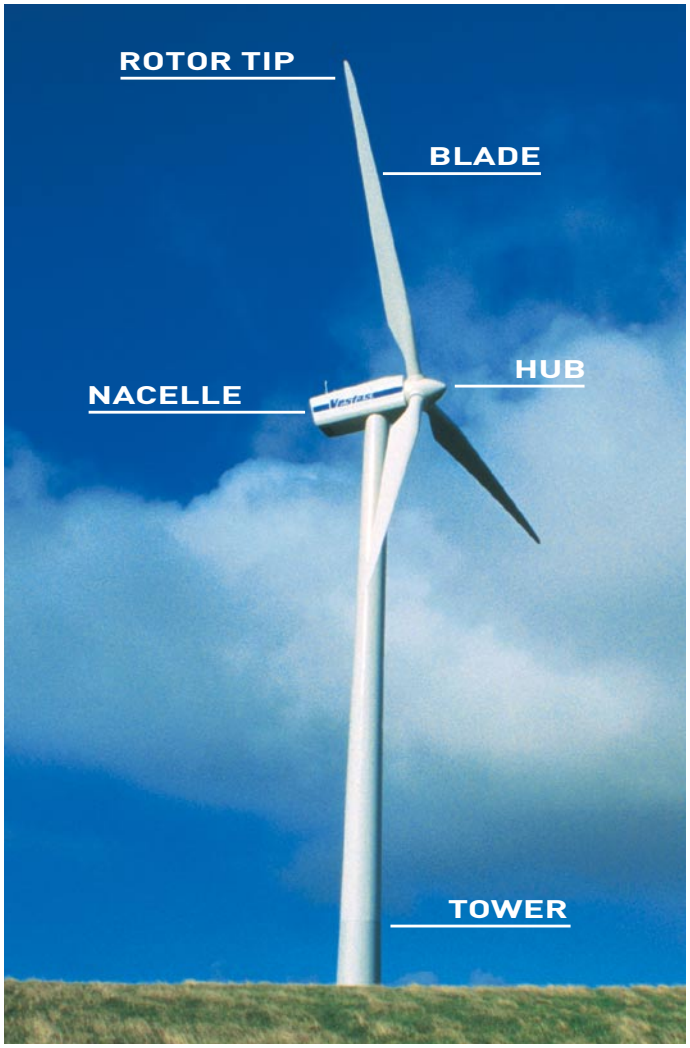
Wind farms produce electricity directly from a natural, clean and sustainable energy resource. This technology is now the world's fastest growing electrical generation source and Australia is beginning to see more wind farms proposed due to their environmental benefits.

Every development is different and site specific issues and local planning controls ultimately determine the design and layout of a wind farm. To provide a benchmark approach, AusWEA has published "Best Practice Guidelines for Grid Connected Wind Energy Projects in Australia" www.auswea.com.au.

## What Is A Wind Turbine Generator?

A wind turbine generator consists of a foundation, tower, nacelle and a rotor (three blades mounted on a central hub). The foundation is typically a thick slab of reinforced concrete 12m wide and 3m deep. This is buried in the ground, allowing stock to graze right up to the tower. The nacelle rests on a large bearing which allows the whole machine to be driven by motors into the prevailing wind direction.

Whereas early wind generators overseas were built on lattice towers, in Australia only enclosed tubular steel towers are used. Towers are typically coloured white or light grey as these colours have been found to create the least visual impact. Internal ladders provide access to the nacelle which contains the drive-train, gearbox, generator and controlling equipment. Wind turbines for today's wind farms cost up to $3M each.



## How Do Wind Generators Work?

The rotor turns a generator inside the nacelle, converting some of the wind's energy to electricity. As wind speed increases, more energy is delivered to the wind turbine's rotor. This energy is extremely sensitive to wind speed - doubling the wind speed gives eight times the energy.

Wind turbine generators deal with these huge variations in power using several aerodynamic strategies that regulate the power captured by the rotor.

| Wind Speed (m/s) | Wind Speed (km/h) | Operating Strategy |
|---|---|---|
| <4 | <14 | machine shut down – not worth wear and tear |
| 4– 12 | 14 - 45 | output increases steadily with increasing wind speed |
| 12 – 25 | 45 – 90 | output remains steady and excess energy "spilled" from rotor |
| > 25 | >90 | machine shutdown for self protection |

## Blade Speed and Materials

The blades of grid connected wind generators range between 25 and 50 meters long and typically sweep to about half way down the tower. Depending on the size and design of the machine, the rotor will turn at between 10 and 25 revolutions per minute. From a distance this rotation seems quite slow and stately. Up close the strength, flexibility and speed of the rotor blades is revealed.

The blades are made from advanced composite materials that have high strength and are light weight and flexible. The maximum blade tip speed is about 215 km/h and it is quite normal to see the blades flex backward several metres under the enormous pressure of the wind.

Integrated lightning protection systems ensure the blades can withstand a direct strike without serious damage. In Australia towers are nearly always steel, whereas in Europe concrete towers are also used.

## Where Are Wind Farms Sited?

Wind farms are usually sited where there is a good wind resource, access to transmission lines, local community support and plenty of open land available. Typically, the best wind resources in Australia are in coastal regions or inland at higher altitudes. Wind farms are unlikely to be built offshore in Australia in the near future because of the extraordinarily high cost of offshore construction. Nonetheless, in Europe offshore wind farms have become economically viable because of higher energy prices.

## How Much Energy Does A Wind Turbine Produce?

This depends on the size of the machine and the wind resource. Typically each wind turbine can can produce enough energy to meet the needs of up to 1,000 homes, saving several thousand tonnes of CO2 emissions per year.

## How Do The Costs Add Up?

Wind power and other renewables are economically viable in Australia because the Federal Government, like many governments in the world, is encouraging the uptake of renewable energy through legislated measures. The Mandatory Renewable Energy Target (MRET) requires that a certain amount of the energy sold by Australian retailers be from renewables such as wind and solar.

Currently wind energy costs around twice as much as energy from coal generation, but the cost of wind power and other renewables is falling. Importantly, the cost of fossil fuel based energy does not factor in environmental costs and should these be imposed in the future (as seems likely), the gap between wind and fossil fuel based energy will close rapidly. In more remote parts of Australia where fuel costs are higher (eg because of transport of diesel), wind energy can be cheaper than fossil fuel based generation.

## Where Can I See A Wind Farm?

Wind farm locations can be found by visiting the Australian Wind Energy Association's web site www.auswea.com.au. Most wind farms have viewing areas with informative displays, some with self guided or commercial tours. Some of the larger wind farms have "virtual tours" on their web sites.

Please remember that most wind farms in Australia are located on private property. You should keep to the path and designated visitors' area and not enter private property unless invited.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 2

# Wind Farming & the Australian Electricity System

## How Do I Know Wind Farms Are Reducing Greenhouse Emissions?

Whenever a wind farm is operational, its output is being fed into an electricity grid and the energy is being used somewhere in the system downstream. Although the contribution of wind energy is currently quite small relative to the total generation on Australian electricity networks, every unit generated from wind is a unit that does not need to be produced by other generation, 90% of which comes from fossil fuels. The type of generation actually displaced (and hence the emissions saved) by wind energy, will vary depending on the geographic location of the wind farm and the time of generation.

## How Much Fossil Fuel Does Wind Power Offset?

Depending on where it is located in Australia, a typical new 50 megawatt (MW) wind farm displaces between 65,000 and 115,000 tonnes of carbon dioxide - equivalent to leaving tens of thousands of tonnes of coal in the ground each year. The amount varies depending on what type of fossil fuel the wind energy is displacing.

## What Happens When The Wind Stops Blowing?

The output of fossil fuel fired generators can be controlled, wind power cannot. Presently, wind power variability has no impact on the operation of most large Australian electrical networks because it still makes a relatively small contribution to the total generation. Today when wind farm outputs increase, the fossil fuel generators simply back off, and vice-versa when output decreases. Networks have to be able to accommodate changes like this all the time because of fluctuations in load.

In the future, more wind farms will be built and the percentage of the electricity from wind will increase. How well the networks cope with this depends largely on the type and size of fossil fuel generation being used, network operational policy, and whether the lessons learnt from other places in the world can be applied.

In some parts of Germany, wind energy can contribute up to 70% of a region's electricity needs. This has required the use of long term wind energy forecasting and changes to the way that these networks are controlled. These changes have been driven by a desire from community and Government, to see the environmental benefits of wind energy increased.

It has also been found that as more wind farms are built, their combined fluctuations and hence overall impact on electrical networks are reduced. This is because wind speed depends largely on local weather patterns and these become more diverse the further they are apart.

## How Predictable Is Wind Power?

Wind power output is intermittent, but the output from wind farms can be usefully predicted as much as 24-48 hours in advance. With increasingly effective data collection across Australian wind sites, forecasts are likely to improve with significant benefit to network managers.

## How Does Wind Energy Compare To Other Types Of Generation?

In terms of mechanical operation and maintenance, wind turbines are more than 99% reliable, compared to around 97% for the steam turbines used by coal plants.


Because turbines in Australia are generally located to take advantage of strong and consistent winds, their utilisation rates (the amount of time they are in use) are generally in excess of 95%, which compares favourably with conventional power plants. Wind turbines are very efficient in converting the primary fuel (wind) to energy. Today's large scale machines typically operate at efficiencies of approximately 47%. This compares with coal to energy conversion efficiencies of 30 – 40 % for coal burning plants, where the majority of energy is lost as heat in the exhaust.

## How Much Wind Power Can We Have In Our Energy Mix?

Large scale wind generation needs to work hand in hand with conventional sources. AusWEA has a target of 5,000 MW of wind to be installed in Australia by 2010 - about 6% of Australia's electricity needs. Recent modelling by technical experts has revealed that at least this amount of wind power can be integrated into the national grid subject to wide distribution, strong interconnection and state of the art forecasting. However, there are plans in some overseas countries for wind power to contribute as much as 10% of energy needs by 2010.

## How Can I Help Promote Wind Power?

In almost every State, householders and businesses can elect to pay a little extra on their power bills for "Green Power". Through a process audited by a third party, "Green Power" customers are assured that renewable electricity, equivalent to the normal consumption, is fed into the grid reducing the amount of fossil fuel based generation needed. The collective purchasing power of "Green Power" customers represents a significant benefit to the environment and is a way of promoting renewable energy sources such as wind power.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 3

# Wind Farming & The Environment

## Why Are Renewable Energy Sources Like Wind Power Important?

Most (90%) of the electrical energy used in Australia comes from the burning of fossil fuels such as coal and natural gas. In April 2001, the Renewable Energy [Electricy] Act was passed as one of the measures proposed by the government aimed at reducing human induced changes to our climate. This Act set targets for the increased use of renewable energy through the Mandatory Renewable Energy Target (MRET). Wind energy is clean, free and renewable. The technology is proven, fast to build and cheap in comparison to other renewable energy technologies. Wind energy is well placed to grow and deliver greenhouse pollution cuts on an increasingly cost competitive basis.

## Is Climate Change Real?

The Greenhouse Effect is a natural phenomenon whereby greenhouse gases trap heat in the atmosphere, keeping earth warm enough for us to habitate. Human activity is however, releasing unprecedented quantities of these gases into the atmosphere principally through the use of fossil fuels. This is believed to be causing too much warming and may lead to accelerated climate change. While the extent and severity of the effects on the environment are uncertain, it is a serious environmental problem for humanity. To avoid dangerous climate change, well beyond what we have seen already, greenhouse emissions will need to be reduced by at least 60% below 1990 levels by 2050. While the "Kyoto Protocol" will reduce emissions by an average of 5% by 2012, it will only be the first of many initiatives required to achieve the massive reductions needed.


## Where Does Australia Rate In Greenhouse Gas Production?

Australia has the highest per capita greenhouse gas emissions in the developed world. Although Australia's emissions contribute only 3.6% to the global total, they are roughly the same as the combined emissions from Austria, Denmark, Finland, Ireland, New Zealand, Norway, Portugal, Sweden and Switzerland.

## Why Are Australia's Greenhouse Emissions So High?

Electricity consumption due to the burning of coal and other fossil fuels, is the most significant source of greenhouse emissions in Australia (45%). This continues to increase rapidly with economic growth. In Australia, around 10% of our electricity is renewable, most of which comes from large scale hydroelectric power stations that were built several decades ago such as the Snowy Mountains Scheme .

## How Much Energy Goes Into Building Wind Turbines?

It takes only a few months for a wind turbine to pay back the energy used in its manufacture and over its 20 year lifetime, a wind turbine will produce more than 50 times the energy used in its manufacture, transportation and erection. Once dismantled at the end of its life, it will leave very little legacy of pollution for future generations.

## Are There Other Benefits To Wind Generation?

Rather than generating a large amount of power in one centralised location, wind farms are often located close to where the electricity is actually used. This means that the losses usually associated with the transmission of electricity over long distances (up to 10%) can be significantly reduced. This further increases the emission reduction benefits.

## How Much Energy Can A Wind Farm Produce?

Depending on siting, a typical wind turbine can produce the equivalent energy needs of up to 1,000 homes. A typical 50 megawatt (MW) wind farm in Australia displaces between 65,000 and 115,000 tonnes of carbon dioxide per annum – enabling tens of thousands of tonnes coal to be left in the ground each year.

## What Is The Impact On The Local Environment?

Wind power offers an environmentally benign means of generating electricity and since the area occupied by the wind turbines themselves is so small, the impact on the natural environment is usually quite minimal. Having said this, wind turbines do need to be located in elevated and exposed places and are often visually prominent in the landscape. There is little doubt that in terms of local environmental impact, it is the visual aspects which will tend to dominate debate. This is addressed in more detail in Fact Sheet # 7. In terms of other local environmental impacts, wind developers are often able to integrate beneficial local environmental measures into their construction and operational activities. This can include the collection of indigenous plant seeds, planting of shelter belts or habitat areas, land class fencing, erosion control measures or easing fire hazard management through improved site access. Income to landowners hosting wind generators can ease pressure on agricultural land by reducing the stocking or cropping of marginal land. In addition, these landowners are often able to adopt superior pest, weed and erosion management practices as well as affording environmental plantings and other land care initiatives.

## What Is The Impact On Wildlife?

Wind farms undergo stringent environmental approval processes including detailed studies of the impact on wildlife. Generally, the adverse impacts if any, will be negligible and positive outcomes can often be achieved through the integration of environmental works by the developer and host landholders.

## How do Wind Turbines Impact Birds?

Monitoring at the Codrington, Woolnorth and King Island wind farms has found bird deaths to be below levels predicted and accepted during the wind farm approvals process. The rate of bird mortality on those sites ranged from between 0.23 to 2.7 birds per turbine per year, none of which was a rare, threatened or endangered species. Putting this into perspective, millions of birds are killed by cars and other man made structures every year. Impacts on Birds are discussed in more detail in Fact Sheet #8.

## What Are The Long Term Impacts Of Wind Farming?

The long term impacts of wind farming are negligible. During operation there is no depletion of the fuel source (wind). When a wind farm is removed, there is no lasting residual impact on the landscape and it can be returned to essentially the same state as it was before the wind farm was built. Most wind farm development approvals have clauses requiring developers to decommission wind turbines at the end of their design life or if they cease operation for an extended period of time.

## How Much Land Do Wind Farms Take Up?

In Australia, the land occupied by wind farms may not be as much of an issue as in countries where vacant land is at a premium (eg. Europe or Japan). Yet in comparison with other energy generation technologies, wind farms still show a greater energy yield per square meter with the impact intensity of wind generation facilities being significantly lower than an equivalent sized fossil fuel based plant :

| Technology | m2 land used per GWh |
|---|---|
| Coal | 3,642 |
| Solar Thermal | 3,561 |
| Photo Voltaic | 3,237 |
| Wind | 1,335 |

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 4

# Wind Farming & Tourism

**Wind farms are usually located in exposed and windy landscapes and the values placed upon these landscapes and the perceived impacts of development upon them vary considerably. Generally, responses depend on both the individual observer and the site being considered.**

Wind farms tend to get more support than many other visually prominent forms of development because they produce clean energy, reduce greenhouse gas emissions and ultimately help mitigate climate change. While climate change is very important, some landscapes should be cherished and protected from all development.

Like other human-made structures such as bridges and lighthouses, well designed wind farms can give interesting perspectives and furnish the landscape with new architectural and heritage values.

In 2001, a poll[1] in Victoria showed that 94% of respondents described wind generators as "interesting" and 74% as "graceful". A subsequent survey[2] showed that 36% of respondents were more likely to visit a coastal area if it had a wind farm, while 55% said it would make no difference. Only 8% said it would deter them from visiting.

The February 2002 survey also showed that 95% of respondents supported the construction of more wind farms. This result was again backed up in a national poll[3] by AusWEA in 2003 which found that 95% support (27%) or strongly support (68%) building wind farms to meet Australia's rapidly increasing demand for electricity.

## Are Wind Farms Tourist Attractions?

Yes. Hundreds of thousands of people visit Australian wind farms each year. Some of these are casual observers who stop at roadside interpretative centres or displays. Others pay to participate in organised tours. In a number of cases, tourists are able to walk right up to the base of the tower, gaining a full appreciation of their size and the power generated by these machines.

In Esperance (WA), more than 80 cars per day travel down the wind farm access roads with the majority visiting the wind farms. Although wind farms have been in operation in the region for over 20 years, visitor numbers have not declined over time.

## What Is The Experien ce Overseas?

Utility scale wind energy is relatively new for most Australians but we can look to the long-term experience overseas. However we need to remain aware of differences – Australian landscapes are generally more impressive and our perceptions of environmental values may be different.

## Tourism Overseas

In Denmark, there are 6,000 wind turbines in an area approximately the size of Tasmania and wind farms there are used for marketing tourism. Hotels, guest houses and camp sites may use wind turbines for "green tourism" promotion. This is particularly targeted towards the German market, where the public is known to have a high level of interest in both environmental issues and new technology.

In a Scottish study[4], 43% of responding visitors said a wind farm would have a positive effect on their inclination to visit the Argyll area, an area of high landscape value. About the same proportion said it would make no difference, whilst less than 8% felt it would have a negative effect.

Surveys in the UK show that for 94% of visitors to North Cornwall, the presence of wind farms has had no adverse impact on the likelihood of them visiting North Cornwall again. The majority of the remaining 6% say that the presence of wind farms would actually encourage them to

revisit. Such public interest has led to a steady increase in the use of serviced accommodation in the area of the Delabole Wind Farm.

## Public Perception Overseas

Research from a wide variety of sources consistently shows that general public support for wind power is between 70% and 80%.

In Denmark since 1991, the share of electricity consumption from wind power has grown six-fold to current levels of around 30%. However, a 2001 poll[5] indicated that 65% of Danes still believed it was a good idea to increase the share of wind energy in the Danish electricity supply. This is exactly the same share of the population as in two previous opinion polls taken five and ten years earlier. Further information on public attitudes to wind energy can be found at; http://www.bwea.org/ref/surveys.html

## Visit a Working Wind Farm?

### Viewing Areas

Most wind farms are located on private land so it is not always possible to walk up to the wind turbines. However in Australia every utility scale wind farm has a viewing area at which members of the public are able to safely pull off the road and learn more about the project. Some wind farms have visitor information centres such as the Visitor Information Centre for the Toora wind farm in Victoria - www.toorawind.com.au/windfarm.

In Western Australia, a major Wind Discovery Centre for the Albany wind farm is being planned by the Albany Council to attract additional tourists to the region - www.albany.wa.gov.au/albany/windfarm/windfarm.

### Self Guided Tours

Some wind farms are located on public land and allow members of the public to walk amongst the turbines at their leisure (e.g. the 9 and 10 Mile Lagoon Wind Farms - Esperance, WA and the Albany wind farm - Albany, WA].

### Commercial Tours

Several wind farms in Australia attract so many visitors that commercial tour operators have been established and provide an opportunity for the public to get a close up view of the wind farm.

- Woolnorth, Tasmania: www.woolnorthtours.com.au/windfarm.html
- Challicum Hills, Victoria: www.windfarmtours.com.au
- Codrington, Victoria: www.myportfairy.com/windfarmtours

### Virtual Tours on the Web

Many wind farms around the world have virtual tours on the web, in particular some of the large offshore wind farms.

1 AusPoll study - June 2001

2 AusPoll study - February 2002

3 Australian Research Group Study - September 2003

4 Tourist Attitudes Toward Wind Farms, MORI Summary Report, September 2002: http://www.bwea.com/pdf/MORI.pdf

5 http://www.windpower.org/en/faqs.htm#anchor29566

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 5

# Wind Farm Siting Issues

## What Do Wind Farm Developers Look For?

Wind developers favour sites with the following attributes:

- Strong and consistent winds
- Winds that blow at times of the day when the electricity is most needed
- Proximity to a suitable electrical grid
- Land where wind farm development is appropriate, away from areas of high conservation value or areas with endangered flora or fauna species [eg. National Parks and wetlands are not considered]
- Identifiable and manageable cultural heritage issues
- Open land without obstacles to the wind flow, and where such obstacles are unlikely
- Broad community support and acceptance
- Low population density
- Good access for wind farm construction and maintenance
- Suitable geology for access track base and foundations

Often a compromise needs to be found amongst these factors.

## Land Use

Wind farming is compatible with many land uses ranging from cropping and grazing properties, to industrial estates, port break-waters and sometimes even forestry. In Australia, wind farms have been built on, or construction is currently proposed for most of these types of land.

Impact on local amenities such as airports, must also be considered when siting a wind farm. The long life span (20-25 years) of a wind farm means that it is also important to consider the future uses of adjacent land.

## How Far Away From Houses Are They Built?

Although wind farms are not noisy in operation they still need to comply with very strict noise standards. It is therefore normally noise criteria that determines their set backs from residences. Setback distances range from about 400m to 1km or more, according to a variety of factors. These include the noise standard prescribed, local topography, prevailing wind conditions and the wind farm layout.

## Why So Much Emphasis On Wind Speed?

The commercial success of a wind farm depends upon its electricity output and the selling price. Wind power in Australia has to compete with some of the cheapest electricity prices in the world, largely due to our extensive reserves of fossil fuel.

The output of a wind farm is extremely sensitive to wind speed. A 15% percent increase in wind speed adds 50% to the energy available. Only a 20% reduction in wind speed halves the wind energy produced. Wind farm developers must therefore, seek out the very best wind resources in order to develop commercial projects.

In Europe where electricity prices are much higher, wind farms can and are built in areas with considerably lower wind resources.

## Where Are The Windy Sites?

Generally it gets windier away from the equator. The southern latitudes of Western Australia, South Australia, Victoria and Tasmania have excellent wind resources. However regional effects such as land/sea interactions, hills, ridges and mountains can enhance wind speeds making an otherwise uneconomic area suitable for wind farm development.

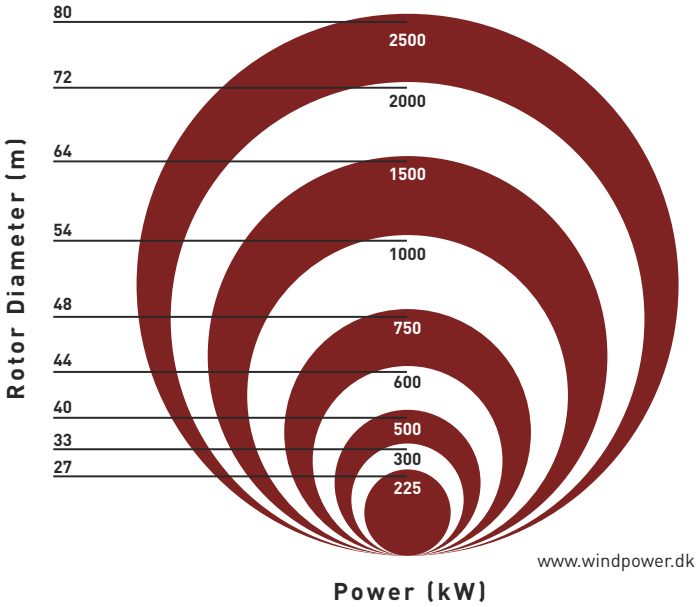
## What Do Developers Avoid?

Wind developers will avoid any site with features that might slow down the wind. The impact of an obstacle will be determined by its height, its width and its porosity to the wind. Obstacles can be natural; ranging from dense forests to scattered trees, or human-made; such as wind rows or buildings. They can not only slow wind down, but induce turbulence which has a negative impact on energy yield and blade wear.

"Surface roughness" is another factor to be considered. Rougher surfaces slow the wind and introduce turbulence into the flow of air. Even a mature wheat crop will slow the wind down more than a closely grazed pasture. Scattered trees will have an even greater effect and big cities have the worst impact. The further the wind travels over rough surfaces, the more the wind slows down. This is one reason why inland sites have lower wind speeds.

## Why Are Wind Turbines So Tall?

Wind speed increases with distance above ground level. In addition, towers must be tall enough to accommodate the rotor which normally sweeps past the tower at about half its height. Power output dramatically increases with rotor diameter as shown below.




www.windpower.dk

## Why Are Wind Farms Put On Top Of Hills?

Due to speed up effects, wind speed is significantly higher at the top of a hill or ridgeline.

## Why Aren't More Wind Farms Built Inland?

Wind farms can be built inland where wind speeds are sufficient and the electricity grid is nearby. Inland sites do however, generally need to be in elevated terrain to be acceptable. Many coastal areas have stronger winds because of their exposure and proximity to the ocean where sea breeze effects are the greatest.

## Why Aren't More Wind Farms Built Offshore?

In Europe there are several offshore developments underway, however they are very expensive to build and cannot be supported by Australia's low electricity prices. In Australia, there is still plenty of room for development onshore.

## How Far Apart Are The Turbines

In general, wind generators will be separated by 3 to 5 rotor diameters across the prevailing wind energy direction and 5 to 7 rotor diameters with the prevailing wind energy direction.

## What Other Issues Impact Wind Farm Layout?

Layout issues are very complex with several factors coming into play in varying degrees according to site conditions. Major factors include local terrain, noise constraints, aesthetic appearance, and avoidance of areas of important native vegetation and sites of cultural or archaeological significance.

Sophisticated three dimensional computer models help developers plot the many complex and often competing issues involved in designing a wind farm. The layout of most wind farms will normally need to go through many iterations before the final design is reached.

## What Influences The Wind Farm Size?

Australian wind farms tend to be larger than European facilities as greater economy of scale is required to make them economically viable. In Australia, wind farms of between 10 and 50 wind turbines are usually pursued.

## How Much Land Is Needed?

Although spread out, less than 1% of the land is used by the wind farm. Theoretically a 50 turbine wind farm could be squeezed into just 100 hectares, but local terrain and other factors usually means a much larger area is required and more than one landholder may be involved. For example, an attractive ridge may take in several land holdings, particularly where the ridgeline constitutes a property boundary.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 6

# Wind Farms & Noise

## How Noisy Are Wind Turbines?

Although wind turbines do make noise, today's modern generators are generally much quieter than most people expect. It is quite possible to carry out a normal conversation at the base of a turbine running at maximum power, without raising one's voice.

The noise at locations within or around a wind farm can vary considerably depending on a number of factors including the layout of the wind farm, the topography or shape of the land and the speed and direction of the wind. It can be accurately measured using acoustic equipment.

## What Do Wind Turbines Sound Like?

The main sound is the swooshing of the blades as they rotate. Sometimes when standing close to the tower, the whirr of the gearbox and generator may also be audible.

An unusual feature of wind turbine noise is that unlike most sources of industrial noise, it increases with wind speed. Around wind farms, many sources of background noise such as vegetation, are also affected by wind speed. At any given location, a wind farm's level of audibility will depend upon the relative levels of noise produced by the wind farm and the surrounding background noise.

When there is little or no wind, a wind turbine does not operate and therefore produces no noise. As the wind speed increases, the turbine commences operation and will start to produce noise which will increase as the wind speed rises. Wind related background noise at locations around the wind farm will also increase. Typically, this background noise rises more quickly and tends to mask the noise from the wind turbines.

The "noisiness" of a wind farm is therefore dependent on not only the level of noise that the wind turbines produce, but also the levels of background noise where the listener is situated. This will vary in different operational conditions.

The sound of a wind farm 100 m away would be inaudible in many urban areas of Australia as it would be drowned out by wind related and other background noises.

A listener's perception of noisiness is influenced not only by how much louder the noise is than that of the existing environment, but also by additional factors which include the acoustic characteristics of the noise itself [ie. whether it has audible tones or characteristics that may annoy the hearer]. All of these factors are considered when setting noise limits for wind farms.

## Low Frequency Noise & Infrasound?

Concern is sometimes expressed about the possible effects of low frequency noise from wind turbines on nearby residents. Low frequency noise was a feature of some early wind turbine designs with the blades down-wind of the tower. This caused a low frequency 'thump' each time a blade passed the tower. Modern wind turbines have their blades upwind of the tower, thus reducing the level of this type of noise to below the threshold of human perception, eliminating any possible effect on health or wellbeing.

## How Does Noise Affect Wind Farm Layout?

Noise limits are carefully determined and result in turbines being located far enough away from occupied houses to protect the amenity of the people living in them. This can have a significant impact on the number and type of turbines included in the design of a wind farm and where they are located.

In Europe, it is common to have wind turbines within 100m of houses. In Australia however, a more conservative approach has been taken and wind turbines are usually placed at least 400m from noise sensitive locations.

## How Does Wind Turbine Noise Compare With Other Sounds?

Levels of sound perceived by the human ear are usually expressed in decibels, denoted dB(A). The "A" represents a weighting of the measured sound to mimic that discernable by the human ear, which does not perceive sound at low and high frequencies to be as loud as mid range frequencies.

- A change of 1dB(A) is the smallest difference one can hear within an acoustically controlled environment
- A change of 3dB(A) is a just noticeable change in level difference in an external environment
- A change of 5dB(A) is a clearly noticeable difference in level
- A change of 10dB(A) is heard as a doubling in loudness of the noise

The following table shows that at 350m, a wind farm has a noise level of between 35 and 45dB(A). In a very quiet rural setting you might therefore be able to hear a wind farm at this distance, depending on the level of wind related background noise.

| Source/Activity | Indicative noise level dB (A) |
|---|---|
| Threshold of hearing | 0 |
| Rural night-time background | 20-50 |
| Quiet bedroom | 35 |
| Wind farm at 350m | 35-45 |
| Busy road at 5km | 35-45 |
| Car at 65 km/h at 100m | 55 |
| Busy general office | 60 |
| Conversation | 60 |
| Truck at 50km/h at 100m | 65 |
| City traffic | 90 |
| Pneumatic drill at 7m | 95 |
| Jet aircraft at 250m | 105 |
| Threshold of pain | 140 |

## Who Determines Wind Farm Noise Limits?

As wind farms have become more plentiful, they have attracted greater regulatory scrutiny. This particularly relates to noise, which is an important design criterion. A regulatory authority, often the state's Environment Protection Authority (EPA), will issue guidelines for noise limits and recommend standard methods to use in predicting and measuring noise. Standards Australia is currently developing a standard methodology for predicting and measuring noise emissions from wind farms, but the setting of noise level criteria will remain the responsibility of the relevant Regulatory Authority.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 7

# Wind Farms & Visual Amenity

## Background

At a local level, the response of the public to a wind farm proposal can vary considerably. To some, the prospect of direct views to a wind farm can be a pleasing addition to the landscape. To others, a wind farm may be seen as an unsightly blight. The response does not only depend upon the particular landscape; it is also affected by the observer and the values they ascribe it.

Wind turbines need to be placed in locations exposed to consistently strong winds. They are large machines and a wind farm will feature prominently in the landscape. In contrast, the impacts of the greenhouse gas emissions that wind power helps to reduce, are predominantly out of the public eye. Large scale coal-fired power stations – the source of 84% of Australia's electricity – are by and large "out-of-sight and out-of-mind".

Wind energy is one of the cheapest forms of renewable energy and its environmental benefits are clear. Polls show a remarkably high level of support in Australia, with one survey[1] indicating 95% support for the building of wind farms to meet our rapidly increasing demand for electricity. Opinion surveys[2] suggest most Australians use words like "interesting", "graceful" and "attractive", rather than "industrial" to describe wind turbines . Nevertheless, a wind farm's impact on visual amenity is generally the dominant issue in the reviews of wind farm proposals and it can be the cause of bitter and acrimonious debate.

The range of views, and importance of considering the context, is demonstrated by the wind farm at Esperance, a coastal town in Western Australia. Here the community actually objected to a wind farm being decommissioned, because residents had become fond of it and identified it as part of the region's cultural heritage. In other cases, wind farm approvals have been withheld because of perceived impacts on heritage landscapes.

## What Is The Industry Doing?

AusWEA recognises that the long term sustainability of the wind industry depends on appropriately sited and sensitively developed projects. AusWEA strongly supports the development of guidelines to inform the assessment of all potential impacts of wind developments, including visual amenity.

Unfortunately, there is currently no universally agreed methodology for assessing landscape values across Australian states. For this reason AusWEA, in cooperation with the Australian Council of National Trusts, is undertaking a "Landscape Values Project" to jointly develop agreed landscape assessment methodologies that can be used by regulators as part of the overall project evaluation process.

The project is divided into three stages -

(i) Stage 1 will scope issues surrounding wind farms and landscape assessment, and solicit possible solutions relevant to the siting of wind farms on the landscape.

(ii) Stage 2 will establish agreed landscape assessment methodologies.

(iii) Stage 3 will trial and test the methodologies.

Stage 2 and 3 are contingent upon the successful completion of Stage1 which has been funded by the Australian Greenhouse Office and is scheduled for completion mid 2004.

## Some Of The Visual Amenity Issues

Visual amenity issues can be broadly categorised into two groups; those relating to the wind turbines themselves and those that relate to their interaction with the landscape. The first category is relatively easy to deal with whilst the latter is much more complicated.

Issues relating to the general appearance of wind turbines, their colour and the impacts of shadows cast, can be reasonably easily managed in the design process. Machines in a given wind farm should be of a consistent size and visual appearance and it has been found that the best colour for wind turbines is off-white or light grey.

For visual amenity issues relating to the surrounding environment, the landscape character needs to be considered along with assessment of the primary views of that particular landscape and the values the community ascribes it. This is important because the way in which we view a landscape, the value we place on it and our perception of the impact of a wind farm on that view, are highly variable and quite subjective.

All of this is complicated by the fact that wind farm layouts are the product of a complex iterative process. The layout that provides the "best" visual outcome may have unacceptable ecological or financial outcomes and vice versa.

## How Should Developers Do?

The first step is to identify the neighbours to a proposed wind farm site and the important public view points, which may vary from a scenic vantage point to simply the main roadway. Through consultation, the developer should familiarise themselves with the visual settings that members of the community and special interest groups value. This allows for a broad assessment of the visibility of the proposal.

During and sometimes prior to the planning application stages, developers are required to prepare photomontages (computer simulations) of how the wind farm will appear from these important view points. These photomontages can also play an important role in the community consultation process, allowing the developer to test different layouts as they develop the proposal in the lead up to a request for formal approval.

## How Can The Visual Impact Of Wind Farms Be Minimised?

AusWEA recommends :

- Extensive community consultation on turbine placement
- If possible, important view points should be agreed with the community early in the process
- The cumulative effect of neighbouring wind farms should be considered
- Wind generators must be uniform in size and design (including direction of rotation)
- Support tower, blades and nacelles should be painted the same colour – preferably off-white or light grey – and have a matt finish. They should not be used as billboards
- All wind generators within a wind farm should be kept operating at once
- The potential for shadow and flicker at residences should be assessed and minimised

1 Australian Research Group study - September 2003
2 AusPoll study - June 2001

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 8

# Wind Farms & Bird & Bat Impacts

## Do Wind Farms Present A Collision Risk To Birds?

Wind turbines, like virtually all tall man-made structures, present a collision risk to birds and bats. The risks however are far lower than many imagine – especially when compared to risks of collision with other structures such as communication towers, tall buildings and transmission towers. The impact of wind turbines on birds and bats is insignificant compared to the impact of domestic cats and the loss of habitat through development or even more dramatically, the chronic impact of ecological change due to climate change and rises in sea level induced by increased greenhouse gas emission. In Australia, collision rates are generally around one to two birds per turbine per year.

## What Are The Other Risks?

Wind farm construction and/or operation may impact the way some birds move about in a particular area. This might include direct impacts on flight, breeding and feeding behaviour as well as indirect impacts due to disturbance associated with construction activity and noise.

## What Do We Know About The Impact Of Wind Farms On Birds & Bats?

Today, bird mortality from wind turbines is probably one of the best researched areas of risk to avian species. Despite some bad experiences early in the US, where wind farms were constructed with little or no understanding about the potential bird impacts, environmental scientists agree that properly sited, today's wind farms present minimal danger to bird and bat populations.

## What Is The Experience In Australia?

Wind farming is relatively new to Australia, but evidence from surveys measuring the impacts of Australia's first wind farms on birds and bats, is starting to emerge. Although several years of post construction monitoring are required to fully understand the impacts, the initial results are encouraging.

- At Pacific Hydro's Codrington Wind Farm in Victoria (comprising 14 wind generators and opened in July 2001) a total of around 20 bird and bat deaths were detected between 2001 and 2003. None of these were rare, threatened or endangered species and the measured mortality rates are well within the predicted estimates. Although there were some early concerns about the potential impact the wind farm might have on water birds, behavioural studies showed that this group was adept at avoiding turbines.
- Stanwell's Toora wind farm in South Gippsland comprises 12 wind turbines. Between 2002 and 2003 six bat corpses were found. Common starlings, Australian magpies and ravens declined in numbers after operations started (although no fatalities were recorded), while the numbers of skylarks and goldfinches increased. Wedge-tailed eagles were regularly observed before and after operations began, but these avoided the turbines by flying around or between them, not into them. The survey found no evidence that the wind farm has caused significant levels of bird mortality and stated that the impact seems to be confined to localised, indirect effects on common, farmland birds. No threatened bird species were observed on the site during a total of two years of surveys and whilst bats have been impacted, the effect is not of conservation significance.
- For Stage 1 of its Woolnorth Wind Farm, Hydro Tasmania has released results of bird studies conducted from October 2002 to October 2003, during which wind turbines were monitored for evidence of any collisions. The wind turbines were monitored daily during peak activity periods and twice weekly

throughout the remainder of the year. These studies show that mortality rates for all species are at the lower end of the levels predicted at the development assessment stage. After October 2003, Hydro Tasmania did report an additional nine birds having collided with wind turbines, one of which was a wedge-tailed eagle, which is a threatened species in Tasmania (but not on the mainland). Under the conditions of its planning permit from the Tasmanian Environmental Management and Pollution Control Board, Hydro Tasmania is required to make a contribution to the species' recovery.

## What are the Regulatory Controls & Measurement Methodologies?

All Australian wind farm developers must currently comply with planning guidelines set out by Statutory Authorities. At a Federal level, all wind farm developments are accountable under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC). This powerful piece of legislation prescribes Commonwealth involvement in environmental matters where an action has or will have a significant impact on "matters of national environmental significance". There is specific reference in the Act to consideration of threatened species and listed migratory species.

In June 2003, the Australian Wind Energy Association was awarded a grant to develop bird impact assessment protocols and dataset standards to assist in data recording and analysis for evaluating the level of bird impact and mortality at Australian wind farms. The work supplements recommendations for bird assessment in AusWEA's Best Practice Guidelines and has been put together with the assistance of a broad range of stakeholders including Commonwealth and State Government agencies, bird experts and non-governmental organisations. This work will help :

- Industry in implementing effective monitoring and in addressing the bird impact issue
- Regulators in setting impact assessment and monitoring requirements as part of the development approval process
- Consultants in designing, costing and reporting impact assessment and mortality monitoring work
- Community and environment groups in understanding the significance of the bird and bat impacts of wind farms.

Importantly, the outcomes will provide a transparent and defensible basis for discussions about bird and bat mortality at wind farms in Australia.

## How Does Mortality Due To Wind Farms Rate Against Other Causes & Compare With Overseas?

A US study[1] published in 2001 carried out by Western Ecosystems Technology puts wind turbine collisions into perspective with bird collisions with other structures :

- Vehicles: 60 million - 80 million
- Buildings and Windows: 98 million - 980 million
- Powerlines: tens of thousands - 174 million
- Communication Towers: 4 million - 50 million
- Wind Generation Facilities: 10,000 - 40,000

The study estimates that wind farms kill an average of 2.9 birds per turbine, per year in the US – equivalent to less than 0.02 percent of the staggering 200-500 million collision related deaths in that country. This estimate includes the fatalities at wind facilities such as those in Altamont, California which were sited in an area of high avian usage and have caused disproportionately high levels of bird mortality.

As the Australian industry enters its next stage of development, more and more information is coming to light that the mortality rates at Australian windfarms are lower than in the northern hemisphere. This appears to be due to the lack of large numbers of night-migrating songbirds in Australia. These occur in the northern hemisphere by the hundreds of millions and they make up about half of the birds that collide with wind turbines.

**Further information can be found in AusWEA's Best Practice Guidelines for Implementation of Wind Energy Projects in Australia, May 2002. www.auswea.com.au.**

1 National Wind Coordinating Committee (NWCC) Resource Document: Avian collisions with wind turbines: A summary of existing studies and comparisons to other sources of avian collision mortality in the United States.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 9

# Wind Farming On A Traditional Farm

**Many wind farms in Australia are on freehold grazing property where the landowner enters into an agreement to host the machines in return for rental payments over the 20-25 year life of the development.**

## Can Wind Farming & Traditional Farming Coexist?

Yes. Most wind farm developers lease only a part of the property for the wind farm - that affected by the turbine footprint and access tracks - leaving the owner to continue their normal farming on more than 99% of the land. Broad acre agro-forestry however is sometimes prohibited because it reduces the commercial returns of the wind farm by slowing the wind. This may not be an issue if the wind resource is good enough.

In some ways, wind farms can be thought of as a vertical crop. Once construction is complete, traditional agriculture can continue underneath and around the wind farm. In most cases the land occupied by the wind farm becomes the most productive part of a holding.

## How Much Land Is Required?

Theoretically, 20 machines with a rotor diameter of 40 meters can be accommodated on as little as 40 Ha. In practice however much more land is usually required after topography and other layout constraints have been taken into account.

Access tracks to each turbine need to be about 5m wide and are made from material like limestone or gravel. Interconnecting cabling between turbines is normally installed underground, alongside the access tracks. By being buried between wind turbines, ongoing cropping is not compromised.

For some developments, a single substation - about 40m by 30m - may be required to house the electrical plant, associated switchgear and metering equipment. Security fencing around the substation is also usually installed. The electrical interconnection to the existing grid is normally a common pole mounted three phase power line.

Developers are required to comply with noise regulations which impact the positioning of wind generators relative to residences. Setbacks from existing residences are usually a few hundred metres and sometimes buffer zones within which no houses can be built, need to be defined. Agriculture however, will normally be able to continue unaffected.

## How Much Rent Is Paid?

Income payable to the farmer is normally agreed on a per turbine basis. Payments vary according to turbine size and wind regime, but are typically in the order of $5,000 per machine per annum.

## What Agreements Are Needed?

Formal agreements range from initial option agreements, which may give the developer the right to collect wind data and other feasibility studies over a few years, to full lease agreements. These set out the responsibilities and obligations of both parties over the life of the wind farm project. Owing to the long life of a wind farm, the developer's rights will need to be transferable to any future purchaser of the host property.

## What Are The Impacts During Construction?

Construction typically takes around 12 months. During this time there can be relatively high impacts compared to those experienced during ongoing operation, including frequent traffic movements that could cause disturbance.

All weather access tracks are built to link the wind turbines and can dramatically improve access across

the property. Where possible, the existing farm track network is used. New fencing and gates may be required where access tracks cross pre existing fences. As part of these works, there is sometimes an opportunity to create laneway systems for stock.

Trenches and excavations are generally left open for only a few days. Appropriate fencing is used during this period. Each foundation takes approximately one week to prepare and a day to pour. The formwork is removed from the foundation a day or two later and backfilled within a week. Following approximately 4 weeks of curing, the wind generators can be erected.

Several foundations may be constructed in parallel and typically, the excavated material is stockpiled for back filling and road making. The large volumes of concrete required are mixed on site using a mobile batching plant.

Impact on livestock is minimal provided there is good communication between farm management and the construction team. Electric grids can be used to control stock as gates will generally need to be left open during construction hours to minimise delays to traffic. Stock must be kept away from excavations, usually using mobile electric fences. Alternatively, stock may need to be moved from a particular paddock for a short period of time.

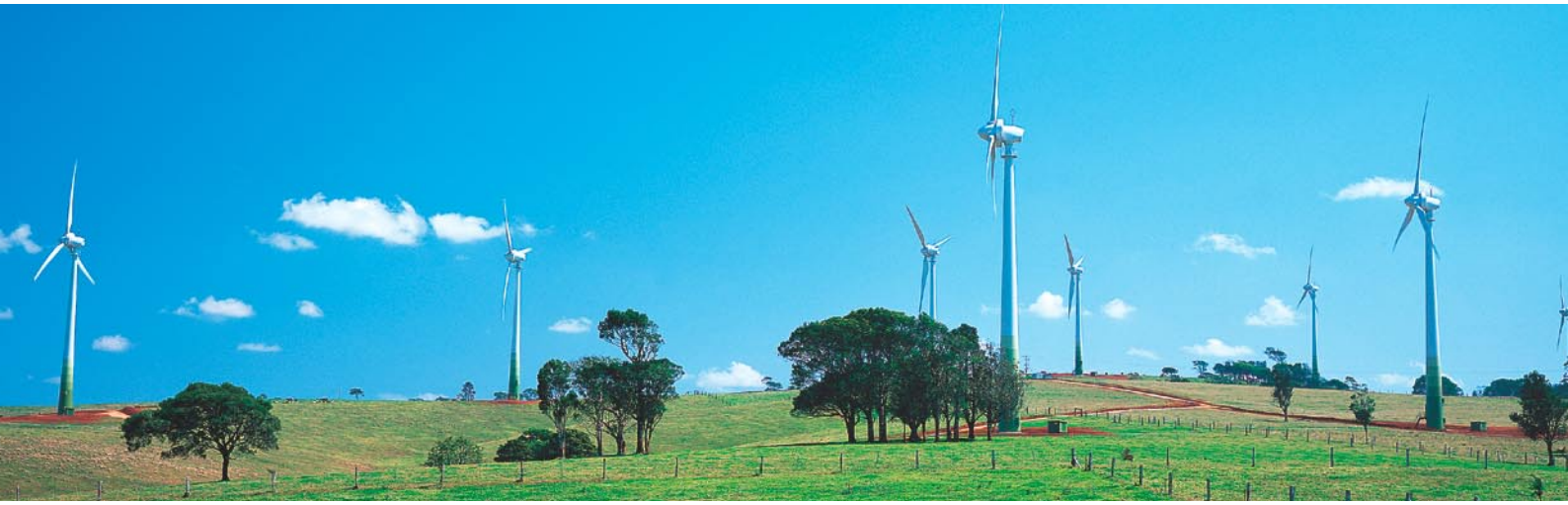
Impact on cropping is mainly due to the access tracks. Normal sowing patterns may be disrupted as it is unlikely that turbines will all end up on unproductive land or in the corners of paddocks. This said, careful planning and consultation will usually enable the landowner and developer to come to a mutually acceptable outcome.

Generally, pivot irrigators cannot be used in the vicinity of wind turbines because of the large area they occupy.

Depending on the site, agricultural aviation such as crop dusting or super phosphate spreading may be impacted. Agricultural pilots are highly trained and operate very manoeuvrable aircraft at very low altitudes (as low as 2m). They are very experienced in hazard management and the local operator is best placed to assess the potential impact.

Extensive tree plantings can slow the wind and cause turbulence and both of these factors reduce the commercial returns of the wind farm. Stock shelters and environmental plantings can however normally be accommodated.

Local microclimate effects are negligible. In the field measurements show little or no change in air temperature or carbon dioxide concentrations as a result of wind turbine movement and evapo-transpiration from the soil is not changed. Thus moisture content of the soil is unaffected.



Local and passing tourist interest will be stimulated by the wind farm construction. Landowners may receive phone calls from a variety of people including neighbours, the media, government departments, tourism operators, and other farmers considering wind farming, etc. Some wind developers help landowners manage enquiries of this nature.

Construction of new residences or other buildings may be restricted. This may be due to either the impacts on the wind resource, or in the case of occupied buildings, noise criteria. Detailed noise modelling during planning can provide a very good idea of "no go" zones for future residences.

## How Are Farming Operations Impacted After Construction?

Impact on livestock is minimal. Sheep, cows and horses are not disturbed by wind turbines and typically graze right up to the base of the towers which they often use as rubbing posts or for shade.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 10

# Wind Farming, Electromagnetic Radiation & Interference

## What Is Electromagnetic Radiation?

Electromagnetic radiation (EMR) is a wavelike pattern of electric and magnetic energy moving together. Types of EMR include X-rays, ultraviolet, visible light, infrared and radio waves. As a natural phenomenon, EMR is emitted by natural sources like the Sun, the Earth and the ionosphere.

Radio frequency (RF) EMR is commonly used for a wide variety of communications applications from the broadcast of television and radio, through to radars and mobile phones. It is important that wind farms do not impact the quality of this communication.

## Is EMR Safe?

Whilst higher frequency EMR [eg X-rays] can be damaging to human health, only long-term exposure to very high levels of radio frequency (RF) EMR will heat or burn biological tissue. The levels of EMR that members of the general public are normally exposed to are far below these dangerous levels.

## What About Electromagnetic Fields?

Electromagnetic Fields (EMF) emanate from any wire carrying electricity and Australians are routinely exposed to these fields in their everyday lives. The electromagnetic fields produced by the generation and export of electricity from a wind farm, do not pose a threat to public health. Typically, electrical cabling between wind turbines is buried in the ground, effectively eliminating any EMF. Grid connection is usually made at no more than 132kV, similar to the voltages used by utilities in existing distribution networks.

## What Do Wind Farms Have To Do With EMR?

From a wind resource perspective, high and exposed sites are attractive. So it is not unusual for any of a range of telecommunications installations; radio and television masts, mobile phone base stations or emergency service radio masts, to be located nearby.

Care must be taken to ensure that wind turbines do not passively interfere with these facilities by directly obstructing, reflecting or refracting the RF EMR signals from these facilities. There is also potential for a wind turbine to actively interfere by producing its own low energy RF signal.

## What Is EMR Interference?

Unwanted radio and background noise can impair effective telecommunications which rely on a strong signal to noise ratio. An appropriate transmitting antenna can dramatically improve this signal to noise ratio. A transmitting antenna can also increase the signal strength in a particular direction (ie toward a receiver). The directionality of a receiving antenna can also be enhanced, thus reducing the amount of unwanted noise.

## How Are Wind Farm EMR Issues Managed?

The impact of wind turbine generators on electromagnetic waves is relatively minor and a means of mitigation, avoidance or remedy can be found for all potential impacts. Any interference can be minimised or eliminated through a combination of appropriate turbine siting and special technical solutions.

Point to Point Communications: Careful siting and directional antennae can eliminate any impact on point to point links.

Mobile Radio Services: Interference can be overcome by moving the mobile unit a short distance away as per normal practice for avoiding any other structure. Any interference to mobile radio services is usually negligible and limited to mobile communications within the wind farm site itself.

Television: Interference to television signals in the wind farm area can be caused by either the reflection or obstruction of the signal by the turbine blades. With glass reinforced plastic blades, modern wind turbine generators will cause minimal television interference. It cannot however, be completely discounted for houses within a few kilometres of turbines.
If interference does become apparent after construction, the possible mitigation techniques include :

- the installation of a better quality antenna or more directional antenna,
- directing the antenna toward an alternative broadcast transmitter,
- installation of an amplifier,
- relocation of the antennae to achieve better signal to noise ratio,
- installation of a terrestrial, digital set top box for digital TV,
- installation of satellite or cable TV, or
- if a wide area is affected then the construction of a new repeater station may be considered.

Active interference is minimised or completely avoided by ensuring that all equipment complies with relevant electromagnetic compatibility standards, as all wind farm equipment does.

In the unlikely event that a problem arises over time at a particular site, the wind farm operator will usually be able to rectify it using one of the aforementioned solutions.

The Australian Communications Authority web site provides details of a variety of television signal interference patterns and ways to overcome these problems - www.aca.gov.au/radcomm/publications/better_tv_radio/index.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 11

# Wind Farm Safety Issues

## How Safe Are Wind Farms?

The wind energy industry enjoys an outstanding health and safety record. In over 20 years of electricity generation with more than 100,000 machines installed worldwide, no member of the public has ever been injured during the operation of a wind farm. The reality is that wind power, like most renewable energy technologies, poses a very low risk to human beings.

## Are Wind Turbines Designed To Be Safe?

Modern wind turbines are sophisticated machines built to last for at least 20 years in all the extremes expected in their operational environment. International safety standards are used in machine design by all major wind turbine manufacturers. Compliance to these standards is audited by third party organisations.

Wind turbines have special inbuilt safety equipment to deal with emergencies. For example, they are equipped with vibration sensors to detect rotor problems and all modern turbines allow complete shut down during excessive wind speeds, virtually eliminating the risk of the turbine rotor or tower failing. In fact wind turbines are considered so safe that at wind farms on public land in Australia, the general public is allowed to walk to the base of turbines at any time.

## How Is The General Public Protected?

Many of the potential risks to the public are reduced by the use of enclosed tubular steel towers (rather than open lattice towers), locking systems on doors, intruder alarms, and protective safety fencing around open switchyards.

Wind turbines do not burn anything to generate electricity and therefore, produce no harmful emissions. The only potentially toxic or hazardous materials involved in the operation of wind farms are relatively small amounts of lubricating oils, hydraulic and insulating fluids. The potential for exposure of the general public to any of these is very small.

## What Are The Air Safety Implications?

Unless they are constructed on or located near airports, wind farms are unlikely to impact on the safety of commercial and domestic air transport . In relation to the impact of wind farms on aviation operations, wind developers are required to liaise with the Civil Aviation Safety Authority (CASA) and the RAAF Aeronautical Information Service, which maintains a database of structures on behalf of CASA. Each wind farm is assessed by a CASA Flying Operations Inspector for its potential aviation risk and any obstruction lighting requirements.

## Do Wind Farms Impact Agricultural Aviation?

The pilots of crop dusting or super phosphate fertiliser spreading aircraft are highly skilled and are easily able to negotiate between the wind turbines which are normally positioned hundreds of meters apart. These pilots regularly navigate other less obvious hazards such as power and phone lines. During the wind farm design phase, landowners (and in some cases pilots) are consulted on the position of wind turbines, particularly any machines near the approach and takeoff paths of unregulated rural airstrips.

## How Do Wind Farms Impact Recreational Aviation?

The operation of recreational aircraft is less predictable than that of commercial aircraft. The array of flight instruments is typically less extensive and sophisticated and often the pilot is less experienced than commercial pilots.

Under Visual Flight Rules, pilots must have good visibility, fly at sub-sonic speeds and must not fly lower than 500 feet above the highest point of the terrain or any object on it. This is well above the height of any part of a wind farm.

## What About Impacts on Hang Gliders?

The nature of operation of hang gliders, micro-light aircraft and model aeroplanes varies considerably. Takeoff points for these activities are sometimes favoured as attractive wind generation sites and local groups need to be consulted during the planning process to assess the impacts. Whilst the modification of activities may be required, they may not need to be precluded altogether.

## Are There Fire Risks?

The risk of fire at wind farms is very low; both fire damage to wind turbine generators and fire caused by the generators themselves. This is because of the following factors :

- The flammable components are located high above the ground
- There is normally no vegetation around the base of the turbine towers
- High-voltage connections are underground
- Access tracks act as firebreaks and provide fire fighting access
- Lightning protection devices are installed on every wind turbine
- Dedicated monitoring and control systems shut down the wind turbines when the threshold temperatures of critical components are reached

## Does Lightning Pose A Threat?

Wind turbines are often struck by lightning, but are equipped with comprehensive lightning protection systems. These systems transfer the high voltages and currents to the ground, without affecting turbine operations. In particular, turbine blades usually have internal lightning conductor rods running all the way to the blade tips.

## Blade Icing

Experience has shown that icing in severely cold weather only occurs when the rotor is stationary. Once operation recommences, blade flexing causes the ice to break off and fall vertically to the ground. Actual "sling shooting" of ice has never been reported.

## What About Safety During Manufacture & Construction?

As with other similar heavy engineering there are occupational safety risks for employees during manufacturing and construction. These include :

- Working at heights (particularly in windy conditions)
- Working with cranes
- Heavy machinery
- Rotating machinery
- High voltage electricity
- Working in hazardous weather conditions
- Driving vehicles

## How Many Deaths Has The Industry Seen?

Since the early 1970's the wind energy industry has experienced 14 worker fatalities worldwide, directly or indirectly during wind farm construction or related accidents. All of these deaths could have been prevented if today's safe work practices had been adopted.

Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au

FACT SHEET 12

# Wind Farms & Land Values

**In Australia, a number of wind farms have been built on or close to private land. There is often debate as to whether the value of those properties has been affected.**

Factors impacting land values include :

- Changes in income earning potential of property
- Aesthetic appearance - impact on scenic views
- Changes in fencing and on site access roads
- Changes in natural vegetation and ecology
- Noise
- General trends in property prices in the area independent of wind farming.

Although no formal studies have yet been carried out in Australia, we can learn from information and studies from overseas.

## What Are The Potential Effects On Land?

The most contentious and subjective issue relating to wind farms tends to be the impact on the landscape and whether the wind farm constitutes an enhancement or a negative impact on visual amenity. From a property value perspective, the greatest actual impact will be if a revenue stream is derived from the development. There is little evidence to suggest that because of landscape values, wind farms negatively impact upon the land values of neighbouring properties.

The effects are not limited to visual amenity considerations. When considering changes in land values, the impacts of ancilliary services such as grid interconnection and roadworks also need to be taken into account . Main road access is sometimes enhanced and in cases where grid upgrades are required to enable the connection of a wind farm, there can be an improvement in the quality of local supply.

Wind farms do produce some noise during operation, but provided the wind farm has been sensitively designed this should not be an issue (see Fact Sheet #6). Similarly, appropriate design is usually able to mitigate the negative impacts arising from shadow and flicker at residences near the wind farm and can ensure that such factors will not impact property values.

Wind farms also bring tourists. Although this can affect landowners by increasing traffic flows, traffic noise & human pressure on an area that may previously have experienced little such pressure, it is unlikely to impact land values.

Wind farms do not have any noticeable effect on stock or cropping.

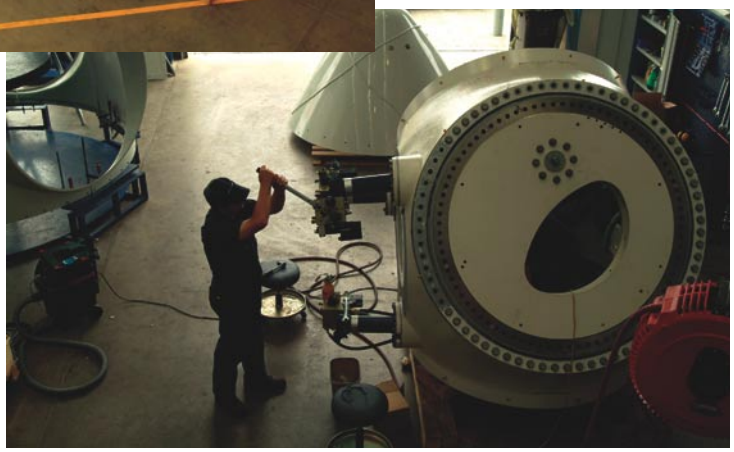
During construction there will be increased traffic movements and generally more activity than normal. This can mean some disruption to land owners caused by the increased noise during this period, but again is unlikely to impact land values.

## What Is The Experience In Australia?

Owners of land where a wind farm is built receive income through land leasing and royalty agreements without impacting farming practices. This can be a very positive result for a rural property and the local rural community. However, landowners should be aware that wind farm agreements typically run for 20 years or more and therefore the impacts of this time frame need to be taken into account when considering any long term aspirations for the property. For example, a wind farm will generally limit rural subdivision potential and there may be a noise buffer of several hundred metres required around the turbines.

In Australia, there is no evidence to suggest that the value of properties with views of distant wind turbines, are adversely impacted by the wind farms In Esperance [WA], an informal investigation was made into property prices

at Salmon Beach, a premier residential area 200 metres away from Australia's first wind farm. Of 15 properties investigated, only one reduced in value after the windfarm had been constructed. This was due to the property being subdivided and sold as two separate lots. Since then, Esperance has seen another two wind farms and 15 more turbines installed without a single negative comment.



Some people simply do not like the look of wind farms and this may influence their property buying decisions. In contrast, a 2001 Auspoll [VIC} survey found that the words most commonly used to describe wind farms were "interesting" (94%) and "graceful" (74%). In some situations, wind projects can provide a 20 year buffer and a net benefit to the landscape and environment by occupying an area that would otherwise have been subject to other development initatives.

## What Is The Experience Overseas?

**USA:** Research in 2002 by ECONorthWest[1] concluded there was "no evidence supporting the claim that views of wind farms decrease property values". This was backed up by a May 2003 Analytic Report for the Renewable Energy Policy Project[2] involving the review of over 25,000 records of property sales within a distance of five miles of wind farms and interviews with property tax assessors. The report found that property values increased faster within the view shed of the wind farm than in comparable locations away from wind farms. The rate of change in average sales price within the view shed was 18% greater over the study period. Once again the report's summary concluded: "we found no evidence supporting the claim that views of wind farms decrease property values".

**Denmark:** A report by the Institute of Local Government Studies (AKF) found that "the economic expenses in connection with noise and visual effects from wind mills are minimal".[3]

**United Kingdom:** A British Wind Energy Association investigation based on a number of different studies, found no evidence that wind farms caused house prices to decrease. This is backed up by the experience of more than 70 operating wind farms in England, Wales and Scotland. In fact, when an opposition group advertised that a wind farm in Glens of Foudland, Scotland would have a detrimental effect on house prices, they were censured by the Advertising Standards Authority (ASA) when the group could not provide evidence to support its claims.[4]

An independent market research study in the UK carried out two public opinion surveys involving hundreds of face to face interviews with residents living near wind farms :

**At Novar Wind Farm, Scotland:** "In regards to house prices, 72 per cent say the wind farm has had no effect, with a further 26 percent saying "don't know". None of the respondents say house prices have decreased as a result of the wind farm." [5]

**At Taff Ely Wind Farm, South Wales:** A new housing development has been built just a few hundred metres away from Taff Ely, with views across open fields towards the wind farm. According to a study[6] 70% say they are able to see the wind farm from their home. "In regards to house prices, 78% say the wind farm has had no effect, with a further 15% saying "don't know". As many residents say house prices have increased a little because of the wind farm (3%) as say they have decreased a little. Similarly, as many say they have increased a lot (1%) as say decreased a lot."

In Nympsfield in Gloucestershire, house prices continued to gain after plans for a wind turbine were announced in 1992. They have continued to increase since the turbine began operating in 1997.[7]


**1. Pheonix Economic Development Group**
http://www.kvalley.com/phoenix/Kittitas%20Wind,%20final.pdf

**2. Sterzinger, Beck, Kostiuk:** May 2003 Analytic Report

**3. Institute of Local Government Studies Denmark:** Social assessment of wind power, Jorgen Jordel-Jorgensen, April 1996.

**4. Renew online:** Wind Works for Farmers, estracts from the Jan-Feb 2002 edition of Renew. http://technology.open.ac.uk/eeru/natta/renewonline/rol35/5

**5. Novar residents survey:** Robertson Bell Associates, July 1998

**6. Taff Ely, Residents survey:** Robertson Bell Associates, December 1997.

**7. BWEA:** http://www.bwea.com/ref/stroud.html



Australian Government
Australian Greenhouse Office

AusWEA
Australian Wind Energy Association
www.auswea.com.au