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Wind Farm Instructional Course

Chris Wheeler*

SUMMARY

This paper provides an overview of the key aspects to developing a wind farm project in Australia. There have been many wind farms built around the world and the design and delivery methodologies are well known. However each wind farm project will have its own issues due to location, changing technology and regulatory requirements. This paper discusses the wind resource, design and development aspects of site selection, land access, turbine technology, network considerations, aspects of contracting, risks and revenue options.

PROJECT DEVELOPMENT PHASES

A good summary of the key activities associated with the development of a wind farm project has been developed by the Australian Wind Energy Association (see Table 1 below).[1]

Table 1

Phase of Project	Technical/ Commercial considerations	Environmental considerations	Dialogue and consultation	Contractual considerations
Site selection	Desktop studies covering potential wind resource, potential size of site, electrical interconnection, land ownership, current land usage and construction	Desktop studies including visual amenity, proximity to dwellings, ecology, archaeological and historical heritage, native title, conservation and	Initial contact with landowners and local authorities. Establish likely development consent process.	

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1 Generally adapted from Table 1 – Project Development Phases and Summary of Activities of AusWEA; Best Practice Guidelines for Implementation of Wind Energy Projects in Australia; March 2002; p 3 (www.auswea.com.au).

Table 1 (continued)

Phase of Project	Technical/ Commercial considerations	Environmental considerations	Dialogue and consultation	Contractual considerations
Site selection (continued)	issues. Preliminary consideration of site potential based on estimated wind speed and capital costs.	recreational uses, electromagnetic interference, aircraft safety and restricted areas.		
Project feasibility	On site wind monitoring, existing land use issues, ground condition evaluation, designs and layout options, site access, grid connection issues and access, economic studies, consideration of development approval requirements. Reassessment of financial viability of the site including wind data.	Clarification and scoping of EIS requirements (if required), assessment of state agency involvement, consideration of EPBC Act implications.	Ongoing dialogue with local planning authority, including Development Application for wind monitoring, strategy for initial dialogue with other agencies and initial discussion with traditional owners (if applicable).	Preliminary landowner agreement and identification of any native title claims and any required easements.
Detailed assessment	Ongoing wind monitoring, wind turbine considerations, requirements for electrical connection, ongoing economic evaluation, tendering for wind turbines and other plant, power agreements and detailed assessment of the financial viability. (Note – turbines may be tendered after DA for greater flexibility).	Environmental impact assessment – studies, documentation and amendments to design.	Ongoing dialogue with planning authorities, statutory agencies and special interest and community groups.	Preliminary connection and access arrangements, easements and leases associated with landowner agreements and native title issues understood.
Development Application	Regulated process – impact statement and approval application(s).			

Table 1 (continued)

Phase of Project	Technical/ Commercial considerations	Environmental considerations	Dialogue and consultation	Contractual considerations
Construction	Site management, environment, health and safety, compliance with approval conditions, contractual obligations, time and cost.	Environmental management plan implementation.	Continued landowner and community liaison and stakeholder management.	Manage project delivery contracts, development condition obligations and landowner lease obligations.
Operation	Performance testing including turbine power, sound output and availability. Compliance with approval conditions.	Ongoing environmental monitoring and management to, as a minimum, comply with approval conditions.	Ongoing dialogue with local authority, submission of monitoring results required under DA and ongoing stakeholder relations.	O&M contract plus support requirements.
Decommissioning	Removal strategy for plant and equipment.	Rehabilitation obligations.	Liaison with local authority and State agencies.	Remove ongoing legal obligations.

Stanwell Corporation has its own experiences in developing, constructing and operating wind farms and this, coupled with the steps in the table form the basis of the material contained in this paper.

SITE SELECTION

Wind Resource

The identification of the wind resource is one of the most important aspects of a wind farm project. The wind resource has the single largest impact on the wind farm output. It is variable and will have specific characteristics which influence the design of the wind farm and the amount of energy harvested from the wind farm.

Identification of a suitable wind resource is achieved using a number of methods. Data records from the Australian Bureau of Meteorology (BoM) can be used to identify the most likely location of good wind sites. This data has been measured over many years but care is required to confirm the data accuracy. This data is only the starting point to selecting a site. Once a region is selected, the next step is to select a location. This means identifying specific areas of land which may in fact yield the expected wind resource. There are also a number of companies that collect and consolidate data for specific areas and will make it available on a commercial basis. These companies could be pure wind farmers or developers who have collected data for a potential development site and then on sell the site and data.

Access to the land is obtained by agreement with the specific landowner or landowners if a project needs to extend beyond more than one property. A landowner agreement is set up with a number of outcomes in mind: (a) future access to the land in the event the project proceeds; (b) immediate access for assessing the projects viability, particularly for immediate monitoring of the wind resource with a local wind monitoring station installed on the property; and (c) identifying the potential arrangement for lease payments to the landowner if the project is proven viable. Consideration will need to be given in the land lease arrangements to ensure that appropriate air passage rights continue for the developer. For example, the construction of a structure or complex adjacent to the wind farm may impact airflow across the site.

The next step is to commence specific site monitoring using wind monitoring towers that have installed anemometers (at various heights), temperature gauges and wind direction monitors. The data is collected by a data logger and this is down loaded periodically to build up a data base of wind information. Ideally the monitoring towers should be set up to the height of the turbine hub (the height of the turbine nosecone) which will give a representation of the wind resource for the site. As the wind gets closer to ground level, it is affected by the topography and other ground features such as trees which generally make the wind speed lower as it approaches ground level. This characteristic is defined as “wind shear” and measuring at levels below the intended installation height of the turbine will not give representative data for the conversion the wind resource to energy. Data is usually taken at a number of heights along the wind monitoring tower to be able to assess the wind shear for the site (which can be location specific) and apply compensation factors for the energy output from the site. This is particularly useful in the situation where a 50 metre monitoring tower might have been installed and the hub height is now expected to be 68 metres or 78 metres as the design of the wind farm has progressed. A number of specialist consultants are able to assist in providing these assessments. Measurements may also be required at different heights as required for environmental noise assessments (eg 10 metres for accordance with relevant South Australian Guidelines).

Given that the project economics rely substantially on the wind resource, the accuracy of the wind data is very important as the investment horizon for wind projects is usually in excess of 15 years. Generally it is expected that at least two to three years of data measured on the site would be minimum and this would be compared against other data which may be available, for example, BoM data from a weather monitoring station close by. A correlation is performed between the on site records (which are for a relatively short period) against the BoM data for the same period. If the correlation is good between the two data sets, then the data from the period outside the site monitoring from the Bureau of Meteorology can be used to assess the long-term prospects of the site. This relies very much on the extent of the BoM data (or other such data) quality for the extended period.

The outcome of this work which is usually performed by the developers and specialists, forms the basis of the assessment of the wind resource. There are two key parameters in determining the characteristics of the wind resource: (a) long-term average wind speed which is used to calculate the long-term energy harvest form the site and the correlation (or confidence level) of the wind resource to actually deliver this long-term output; and (b) the variability of the wind speed, for example, gusting and variability on a daily and seasonal basis. The average wind speed has a probability of 50 percent of being achieved and the actual result may be higher or lower which will be dependent on the variance of the data. The probability of actually achieving a particular average wind speed allows developers (and more particularly financiers) to check sensitivities of the wind farm output. For example, the correlation can be used to determine the 90 percent probability of a wind speed being achieved which will be lower than the average – 50 percent probability wind speed. This result can be used to re-run the financial modelling to establish the sensitivities of the project to data variability.

If there is no BoM data for correlation purposes (BoM site should be less than 150 kilometres from the development if possible), then the risk level of the project to wind resource variability increases unless other data can be established for correlation purposes.

The measured wind data also provides other information, such as the variability of the wind over the day and seasons, the gusting properties and predominant wind directions which are necessary for the engineering design of the wind farm and the final selection of turbine equipment. The monthly variability may be significant for cash flow purposes, particularly if the project is to be debt financed.

Site Accessibility and Topography

While a good wind resource may be available on the rugged cliffs of a coastline or island, the impact of topography on the constructability and maintainability of a wind farm needs to be considered in the site selection and design phases. Key accessibility and topographical evaluation considerations are discussed below.

Constructability

The erection of any commercial size land based wind farm today will require large cranes and delivery trucks that can get access to the areas where turbines will be erected. Cranes of substantial size and weight (600 tonne lift capacity and 100 metre reach) may be required to be dissembled, transported and reassembled on site. Consideration needs to be given to where the turbines can actually be located to take into account any limitations which might be caused by site terrain and its accessibility to large equipment.

Logistics

Issues such as load sizes, bridge loadings, port unloading, site access and grades plus special transportation permits will need to be investigated. For example, Western Australia limits movement of large loads during school holiday periods.

Internal roads and cable routes

Internal roads are the backbone of any wind farm construction and ongoing maintenance. Care needs to be given to the layout particularly for erosion control.

Erosion

Steep hills and sites will need greater care for ongoing erosion control and the flow of any redirected water.

Ongoing maintenance

The ongoing maintenance of the facility needs to be considered once the construction work had been completed. In conjunction with the rehabilitation requirements of the landowner, the widths of various internal roads may need to be reduced from the construction requirements and construction hard stands closed over.

Rehabilitation

The developer will need to consider the extent of rehabilitation which is necessary and this will need to be considered in conjunction with the landowner, who may want to carry on with activities which they had been conducting prior to the development of the wind farm.

Connection

Proximity

The proximity of a wind farm to the power grid to enable a connection to be made is a very early and important consideration for two reasons. The cost of interconnecting equipment is high and the specific voltage which is available for a connection to be made, also governs the type of HV substation equipment and the costs increase as the voltage increases. In larger wind farms (50 MW and above), it is not be unusual to see connections made at 132 or 275 kilovolts. In addition to the technical aspects and costs, if the line is to be a relatively lengthy line, there will most likely be a number of properties which the line will traverse and consideration will need to be given to the time and costs to secure easements. In most cases, this will come under the responsibility of the Network Service Provider (NSP), but even though they may have compulsory acquisition rights, this is usually a last resort and they will try and negotiate with the various landowners in the first instance.

While the NSP will generally be responsible for the power line construction, there may be reluctance on their part to manage or even provide services relating to route selection, easement negotiation and statutory approvals for the power line(s). The power line(s) may need to be included in the development approval application for the wind farm. The development approval for the wind farm project will, as a minimum, likely require aspects of the power line construction to be monitored on the development site for environmental impacts.

Capacity

Transmission lines have capacity limits on their ability to be able to transmit power. If an existing line is substantially loaded, even though a connection can be achieved, the ability to transmit power over the full operational range of the wind farm may not be achievable. Network studies need to be undertaken early in the project to determine any limitations. The NSP will normally conduct these studies (at commercial rates) and advise if full power transmission is possible, or if there are limitations and conditions in their network which will prevent the transmission of full power. An assessment then needs to be undertaken as to whether further "deeper" network augmentation may be required or if the probability of the event is so rare, that the proponent is prepared to carry this risk. It is not unusual for these conditions to be documented in the Network Access Agreement (or Network Connection Agreement).

Stability

A more recent requirement of the NSP for wind farms is ride through and stability of the network under faulted network conditions. A faulted network condition is where the network experiences a "short circuit" or similar occurrence, such as a lightning strike. This causes the various generators on the network to behave substantially different to normal operational conditions. Previously wind farms have removed themselves from the network under these conditions, and have left the rest of the generators to remain connected, such that when the fault is removed, normal power flows can re-establish. If there was a substantial amount of wind generation on the network at the time and it simultaneously disconnected, generation may not be able to match the load after the fault has cleared, leading to further instability of the network. NSPs are now requiring that wind farms provide similar performance to a steam or gas powered generating plant. Inherently, wind farms are not designed for this performance and additional equipment is required to support their operation during these faulted conditions. This adds additional equipment, complexity and cost. Very specific and detailed studies are required to carry out the assessment of what is required.

The output of these studies is used to select the size and type of electrical equipment which is required to be added to the network in addition to the normal connection equipment. It is not unusual for the NSP to limit its liability and provided limited warranties on the outcomes of these studies and great care needs to be taken to ensure the assessment is correct, otherwise additional costly modifications may be required.

Land Access

Access to the development site is generally achieved by a Land Lease Agreement. This Agreement covers the provisions for the construction, operation and decommissioning of the wind farm; any rights which the lessor may have in respect to ongoing operation of the land (eg cattle grazing); the normal legal provisions for liability and insurances and the agreed payment formula for the lease of the land. There are a number of formulas for payments with the most common being a royalty based on the actual energy sales or a fixed lease payment.

Stakeholders

The management of stakeholders and their expectations should be understood for any wind farm development. The typical stakeholders are listed below.

- Wind farmers
- Neighbours
- Community
- Council
- Indigenous people
- Business (local)
- Contractors
- Network company
- PPA offtakers
- Government agencies
- Non-government organisations
- Other proponents.

The form of engagement with each of the groups will take place at different times and in different forms as the project proceeds through it development lifecycle. There will be the need for community engagement (including public meetings) as a part of the Development Approval (DA) process. However, there will also be the requirement for one on one meetings, for example with the neighbours and wind farmers. There is likely to be a series of meetings with the indigenous representatives for traditional ownership of the land and a requirement for archaeological and anthropological surveys.

Council will need to be kept informed of progress on a regular basis and may require periodic reports, particularly if there are developments in the project which may cause delays for some reason.

The relationship with the NSP is important and good communication is required. There may be limited access to the network in the prospective area of the development. Network studies will need to be conducted to provide advice if the wind farm is able to operate reliably on the network or deeper network modification is required. There may also be other developers in the same area, which may have the impact of limiting the development if they are allowed also to connect to the grid.

Retailers who have contracted to take the output will also want to understand at what stage the development is at, and if there are any prospective delays in the delivery of power to meet their obligations.

ENGINEERING

Turbine Selection

The turbine selection for the site is dependent on a number of variables. The following description highlights the more important features which will need to be considered when selecting a turbine supplier and turbine model.

Site rating

A key parameter in the selection of any turbine is the site rating. The site rating is derived from the profile of the wind resource for each specific turbine location and confirms the turbine and ground anchoring for the turbine to perform reliably at that location. The owner will generally require certification to be carried out by an independent agency (eg Germanischer Lloyd (GL), Det Norske Veritas (DNV) or similar certifying agency). The final selection and agreement on the machine model and its certification level to be provided will be developed from the proposals provided by the turbine supplier, along with the owner and usually an independent specialist engineer.

Turbine height

The height of a turbine generally allows a turbine access to a higher wind speed if there is a positive wind shear for the site. Most sites will have a positive wind sheer, where the wind speed will increase in value at higher levels above ground. The energy extracted from a turbine is related to the cube of the wind speed. For example, for the same turbine mounted on a 78 metre tower instead of a 68 metre tower and a corresponding 5 percent increase in wind speed, the energy output would increase by approximately 10 percent. Of course this increased output must be traded off against the additional costs of materials and strengthening in the tower, the extra footing costs to anchor the tower to the ground any effect on the certified site rating which may flow onto a design change of the turbine and blades.

Blades

The size and style of the blades is determined by the wind speed and its variability (gusting) along with the power generation components. A larger and longer blade will provide a greater wind harvest (ie wind swept area) and consequently more energy from the turbine. However, if the wind resource has a gusting characteristic, a longer blade may not be appropriate as it either may fail in service, clash with the tower if it flexes too much or cause undue power fluctuations in gusting situations. The blade design and control is also an important feature in the noise generated from a wind farm. Blades may be fixed pitch or variable pitch. A variable pitch control of the blade will provide better aerodynamic efficiency and this is usually traded against noise emissions.

Coupling to blades

Depending on the turbine manufacturer, the assembly may be provided with or without a gearbox. Gearboxes have been the more traditional component of connecting the blade hub through to the generator. However, sophisticated power electronic technology now allows the blade hub to be directly connected to the generator. This provides the advantage of reduced maintenance costs due to the omission of a gearbox (which had been traditionally an area requiring maintenance) and secondly, the omission of a relatively large noise emitter. However, in the selection of a turbine for a site, the provision of a gearbox or not will usually be a secondary consideration.

Comparison of technology types

There are a number of generator technologies which are supplied with turbines. Each has its own advantages and disadvantages. The comparison is provided in Table 2 below.

Table 2

Technology	Advantage	Disadvantage
Induction generator (constant speed)	Low cost and rugged proven design, relatively good efficiency.	1. Required the network to be live for it to start working 2. Cannot ride through network faults without external additional components being connected 3. Required external components to control voltage fluctuations on the network 4. Mechanical stresses and gearbox 5. Noise 6. Aerodynamic efficiency
Synchronous generator with inverter (variable speed)	Noise, aerodynamic efficiency, no gearbox.	1. Electrical efficiency 2. Cost 3. Complexity
Wound rotor induction generator (variable speed)	Mechanical stress, noise, standard generator.	1. Higher cost than induction generator 2. Gearbox 3. Converter in rotor circuit

Other Design Considerations

Noise boundary

Noise is generated from a number of sources: blades moving through air, blades moving past tower, gearbox, cooling fans, and transformer hum. The wind turbine designer must consider each of these influences in its final design of components to ensure the turbines are capable of meeting the guarantees which are in turn used to model the total noise emitted from the wind farm.

An assessment will be required of the noise likely at the project boundary and other identified sensitive receptors. This will require the ambient (or background) readings to be taken at various locations and times around the site and sensitive receptors, the turbine model to be selected and the preliminary layouts of the turbines to be undertaken. Once this is achieved, an assessment of the noise levels at the boundary and other locations can be assessed which is then fed into a series of iterations to optimise the noise levels and site energy production.

Geotechnical aspects

Geotechnical surveys should be conducted on the site to assess the variability of the ground conditions around the site and to allow preliminary design of the turbine footings to be undertaken. Due to the costs of concrete and reinforcing steel, it is normal to have at least a preliminary geotechnical assessment performed prior to firming up the prices for turbine installation.

In addition to the ground conditions, the general site contours should be examined to determine underground cable routes and road layouts. It is not unusual to have many tens of kilometres of roads and cable trenches on a larger wind farm.

Occupational health and safety

The various occupational health and safety (OHS) aspects of the site will need review. Generally an assessment of the OHS requirements for man lifts versus manual climbing, specialist training and services for HV operations and working on remote sites will be conducted early in the project development.

Turbine siting (wake loss, interaction, site rating)

Turbine siting is influenced by noise considerations and site rating (previously discussed), wake losses which are caused by dirty air from adjacent turbines and the general limitation a turbine manufacturer may have in relation to the proximity of turbines to one another. A series of siting iterations is usually required to find the optimal layout.

Radio, television and wireless communications (eg – mobile phones) – potential interference

An assessment will need to be conducted on any impact that turbines may create on existing communications and radio/TV signals. Desktop studies and specialist surveys may be required to ensure there is no impact to existing services. The Australian Communications Authority should be contacted to advise them of the project.

Aeronautical safety

Consideration will need to be given to aircraft safety. Approval from the Civil Aviation Safety Authority (CASA) is required for all structures over 110m in height. CASA conditions of approval may include the requirement to install aircraft warning lights on towers within the wind farm. As there are no statutory approval time frames, the time required to gain approval from CASA should not be underestimated.

Site communications

A large number of wind farms are relatively remote and consideration will be needed to the level of external communications required. This will involve phones, facsimile and general data transmission. In some instances, satellite or CDMA mobiles may be the only realistic alternative to land based communication mediums.

Maintenance and operations

The method of maintenance and operations will influence the level of automation and external surveillance capability of the turbines.

VAR compensation

VAR compensation is required to stabilise the voltage in the network (ie to stop voltage fluctuations which impact things like light flicker and the performance and possible premature failure of other electrical equipment). It is normal to have VAR compensation equipment installed as part of the turbine. However, it is not unusual for equipment to be installed as a part of the substation design.

Ride through

The Australian Energy Market Commission National Electricity Rules and Western Power Technical Code both require proponents to have wind farms that are capable of riding through faults which occur on the external electricity network. The solution to this requirement is to provide additional electrical and control equipment as a part of the turbine or substation system (or possibly both).

DEVELOPMENT APPROVALS

The development approval process will be set by the requirements of each State and local government. The nature of the proposal (including size and environmental impact) will also affect whether the proposal is managed at either a State or local level. For example in Victoria, the Minister for Planning is responsible for assessing all wind farm proposals over 30MW. However in South Australia, most wind farm proposals will be assessed at the local level (unless deemed a "Crown Development" or "Major Development").

Required referral agencies will depend on the nature of the proposal and State and local planning legislation as well as the discretion of the administering authority. Agencies may provide advice or have the right to impose conditions. For example, in most State jurisdictions the Environmental Protection Authority (EPA) (or its equivalent) will be a referral agency for noise related issues.

Approval from the Federal Environment Minister may be required under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act specifies matters of national environmental significance (MNES). Where a proposal is likely to significantly impact on a MNES, approval under the EPBC Act is required. Proposals may be referred to the Federal Minister under the EPBC Act to seek a determination on whether or not they constitute a "controlled action" and hence if approval is required. This process has the benefit of providing some surety to the proponent. Where Australian Government approval is required, differing levels of assessment may be applied. Bilateral agreements with a number of the States allow the State assessment process to be utilised as the Australian Government assessment process. However formal Australian Government approval is still required at the end of the assessment process.

Approval from CASA is required for all structures over 110m in height.

Victoria, Western Australia, and South Australia have produced State wind farm planning guidelines which outline matters that should be considered in assessing a wind farm development. The application will be completed on the standard application form, with the relevant supporting material. The key parameters which will need to be studied and submitted with the application are discussed below.

Flora and Fauna

Surveys of the local flora and fauna will need to be conducted and assessed if there is to be any likely impact due to the construction or operation of the wind farm. A great deal of interest will be placed on the bird and bat population in the area and the likely impact on these flying species, particularly in regard to "birdstrike" or the likelihood of mortality due to a bird or bat coming into contact with a rotating blade. Terrestrial flora and fauna will potentially be more particularly impacted during the construction phase. Construction of access roads, turbine footings and the power line and substation infrastructure may cause disturbance and habitat loss. Some of the impacted areas may present opportunities for revegetation after construction is completed, but a substantial part of the infrastructure remains in place for the ongoing operations and maintenance.

Assessment of the likely impact will need to consider the species status (eg common, threatened or endangered) and whether the proposal will impact local and or regional populations. This is a specialist's area. They will assess existing information sources and determine the requirement for site surveys. Project schedules need to take into account the seasonal requirements for surveys. It is not unusual for a condition of the DA to require an ongoing requirement for bird and bat mortality monitoring. Annual (or more frequent) reports may be required for a number of years after the commencement of operations. In addition to surveys undertaken by qualified specialists as part of the monitoring program, site operating staff may be trained to recover animals for a post mortem analysis at other times.

Visual Amenity

Councils will generally refer this item to the States' EPA or agency charged with dealing with the matter. For example, in South Australia, this will be dealt with by the local council. In most cases, proponents will be requested to provide an assessment of the impacts of visual amenity. This will generally cover the impacts on local residents, travelling public and any other specific aspects such as tourism and aesthetic value. A written report is usual, with an assessment of the impact on each of the potentially affected areas. In some cases, a "photo montage" of specific locations will be requested which then requires actual photographs to be taken of the view which is to be assessed. At this stage the wind farm design must be sufficiently known, that is the approximate layout and height of the towers and blades. These two pieces of information are combined in a computer simulation to provide an image of the equipment once it is installed. Computer animation can also be used to provide images of the view, with the turbine blades rotating. This is unusual for a submission, but can be useful as part of the stakeholder information process, particularly neighbours.

Noise Emissions

Methodology for assessment of noise from wind farms is different from that of most other industrial developments. Typically industrial noise is assessed at low wind speeds to avoid the interference of wind generated noise. However a wind farm does not operate under these conditions. A fairly consistent methodology for assessment of wind farm noise now seems to be applied across Australia (ie either of the methodologies given in the NZ or SA standards). These methodologies provide for the setting of limits which will vary with wind speed and are based on the existing background (without wind farm operating) noise levels. However, compliance limits imposed vary from State to State.

Neighbours external to the development site, are considered “sensitive receptors” and the wind farm will be required to comply with the noise criteria at these receptors. Noise modelling of the proposed wind farm design will be required to confirm compliance of the wind farm with the noise criteria at sensitive receptors

In some cases, councils will also assess how noise may affect areas of land which are not yet developed and may have future residential premises built.

Finally the DA will most likely impose conditions to undertake compliance monitoring once the wind farm is built to demonstrate that it is meeting the imposed noise criteria. The requirements for monitoring may vary from complaint driven monitoring to a significant ongoing monitoring requirement.

Flicker

Flicker is an important issue which must also be considered. It occurs when the position of the sun and a turbine(s) align so that light flow may be interrupted to a sensitive point, usually a residence or area where human habitation will occur on a relatively frequent basis. The allowable limits for flicker are generally considered to be acceptable if less than 20 hours per year. Consideration will need to be given to the layout of the wind farm or relocation of the residence or particular situation if this value is exceeded.

Culture and Heritage (European and Indigenous)

Proponents will need to consider the impact of the project on the cultural and heritage issues which may exist with the site. Initial assessments of the ethnographic and archaeology will need to be carried out, with identification and involvement of the Indigenous people who have an interest in the area. Also, any native title claims over the areas will need to be checked and if so, engagement commenced with the claimants. At the Australian Government level, sites of significance are listed in the Register of National Estate.[2]

Impact on Communications (Electromagnetic Interference)

Very early in the development process, the proponent should carry out investigations into any potential impacts which might occur to radio, television, mobile phone and other communications medium. This is a specialist area and will require the services of a specialist consultant, who has set up the appropriate databases of communications equipment. Later in the development phase, it may be necessary to carry out base line signal measurements of the various communications systems in the local area to establish a base line for any ongoing complaints.

2 Register of National Estate (RNE) available at www.ahc.gov.au.

Local Employment and Industry Participation

Due to most wind farms being developed in regional areas, local councils are sensitive to community expectations of training and employment in addition to any statutory obligations required of a developer. In the number of wind farms that have been developed by Stanwell and others, various initiatives have been adopted to provide basic training to position the trainees to be eligible for employment by the contractors building the wind farm. The training may cover computer skills, specific requests which are put forward by the stakeholders (where practical and possible) and various machinery operators' tickets.

In addition to this, a number of the local businesses can provide services to a project and they should be utilised where practicable and possible.

PROCUREMENT AND CONTRACTS

Contracting Methods

A number of procurement strategies are available to the developer for the design and construction of the wind farm. The following are the more common approaches.

Engineer procure and construct

The EPC contract is similar to a lump sum turnkey, where a single contract is set in place to engineer procure and construct the wind farm, which includes all the performance testing (although the owner and EPC contractor will generally agree on an independent party for the assessment). The EPC contract is usually prepared by specialist consultants and lawyers or owner in-house specialists if they are available. The projects' risks are allocated in the contract and are usually set out such that the owner will take limited or no risk associated with design, construction and performance. The owner may have to take some risk on latent ground conditions, foreign exchange and wind resource depending on how the contract is structured.

Engineering procurement and construction management

An EPCM delivery arrangement is organised in a manner where the owner hires a specialist project management company to coordinate the EPCM. This arrangement will require an engineering company with expertise in the engineering, construction and commissioning of a wind farm. This arrangement can generally be completed for a lower capital cost, but it is at the expense of risk allocation between the owner, the EPCM contractor, the turbine supplier and the construction contractor. This configuration would generally be performed by an owner who has the appropriate experience.

The turbine and substation supplier will still be required to provide sufficient performance guarantees on the turbines output, noise, reliability and general performance parameters at an individual level and not at an integrated level. Some of this risk will be borne by the EPCM contractor.

Owner build

It is assumed the owner has sufficient in-house experience in designing and building wind farms along with the necessary contracting and logistics expertise. The contract risk premiums are reduced thus saving the owner cost.

However, the turbine and substation supplier will still be required to provide sufficient performance guarantees on the turbines output, noise, reliability and general performance parameters at an individual level and not at an integrated level, thus exposing the owner to risks which may emerge at contract and equipment interfaces.

Network Connection

Connection to the network is one the significant activities associated with a wind farm. Network Service Providers are regulated and are governed by the Australian Energy Market Commission National Electricity Rules[3] in the Eastern States and the Technical Code in Western Australia. In addition to the Rules and Code are the normal application processes, which are designed to deter developers from unnecessarily "banking network access" for extended periods of time, while other developers may have acceptable projects but are constrained from finalising their agreement until the first proponent is dealt with. Each NSP has different arrangements for building the infrastructure. In some cases, the proponent can organise the contracting and delivery of the infrastructure, which may be incorporated into the EPC contract for the total wind farm. Generally, the NSP will require some involvement into the delivery of the infrastructure, either by using in-house arrangements or preferred contractors. In all cases, the NSP will have its own standards for design and construction and will require the proponent to diligently follow their design and installation processes. In all cases the proponent must interface and work in collaboration with the NSP for the actual design parameters (such as insulation levels and lightning protection, communications, signalling, controls and earthing systems). The timing for all these activities and elements to be considered into the design is not without significant effort from the NSP and the proponent (or its contractor). Timing for completion and commissioning of all works is generally one of the most critical components of the project schedule.

[3] Found at www.aemc.gov/rules.php.

Timing

There are number of key time line activities. These are listed below and must be considered in the overall context of the risks to the project:

- Development approvals
- Native Title and Cultural Heritage approvals and surveys
- Access to the site (landowner agreements)
- Finalisation of turbine layout (noise, power, visual amenity)
- Certifications (equipment and site)
- Connection to the grid
- Performance testing.

Risk Allocation

In considering the risks, a risk management plan should be prepared at the commencement of the project development and continuously updated. The following table (Table 3) identifies the most common risks associated with the contracting arrangements and is provided as a guide:

Table 3

Risk	Allocation	Comments
Wind resource assessment	Entity which carried out the onsite measurements. In most cases, this will be the owner with a contracted arrangement to a specialist company who is skilled in taking these measurements.	The contract for measurement and assessment is quite small in comparison to the overall investment in the wind farm. It is likely that a third party consultant will substantially limit their liability to well below what the possible loss might be for a substantial error (refer above to the heading "Engineering"). It is advisable for independent peer review and correlation calculations to a wind resource in the vicinity.
Time	Allocation to the contractors for the delivery phase of the project. Owner must be mindful of a site access and any obligation on the owner in the DA. In addition, depending on the arrangements with the NSP, the allocation of risk for the timely delivery of the network connection needs to be considered carefully. It is usual for a NSP to limit liability for timely delivery and good cooperation (while not ideal from a legal perspective) is a key component.	

Table 3 (continued)

Risk	Allocation	Comments
Network connection performance requirements of the NSP.	The NSP will stipulate a set of requirements for connection to the grid. These requirements will come from their "Rules" or "Code" and the design standards are understood by experienced network engineers. A more significant and variable component of performance of the wind farm is the "Dynamic Performance" of the wind farm when connected to the grid. This involves network studies and will examine aspects such as ride through, voltage stability, power transfers, etc. The information for these studies to be carried out is gained for the NSP and the wind turbine supplier who will build the wind farm. Depending on the NSP, these studies can be carried out by independent specialist consultants or in house by the NSP. The output of these calculations will set key design parameters for the wind farm electrical connection design to allow equipment to be selected. If the equipment is not correct, there may be substantial cost to rework and a period of time for curtailed output while the problem is rectified. If the NSP performs the calculations it is unlikely any substantial warranties would be offered. If a specialist consultant performs the work, then some risk can be allocated to them, usually up to their PI Insurance value. It is critical the wind turbine provider supplies the correct information and consideration needs to be given to allocating the responsibility for this information transfer to the wind turbine provider.	The technical codes specifically address the requirement, however the actual design will be dependent on the network and turbine designs. Most NSPs are very conservative in this area
Power output of the turbine versus the actual wind speed.	This will be allocated to the wind turbine provider.	It is normal to have liquidated damages clauses for output performance. The wind turbine provider will want to limit its liability and consideration needs to be given to what would be a considered a max performance error. As a substantial number of wind farms are constructed using the same turbines, historical information is generally available from previous jobs. However, due to the rapid changes in the designs and models, care needs to be used when looking at historical performance to ensure it is the exact model of the turbine and blades to be provided.

Table 3 (continued)

Risk	Allocation	Comments
Noise	This will be allocated to the wind turbine provider. However the wind turbine supplier will only take risk for the actual emission of the turbine and not the combined output which is transmitted to the site boundary.	Turbine noise output performance is critical to achieving and boundary noise obligations imposed by the DA.
Geotechnical	The owner usually tries to place this risk with the contractor. Depending on how much access the contractor has been given to carry out its own investigation, there is still the potential for a latent condition claim. However, the extent of the claim may be reduced if there was sufficient pre-award investigatory work carried out.	Below ground conditions and other matters such as the discovery of artefacts, can only be truly identified after the ground is broken in all areas.
Energy sales	This risk usually will lie with the owner. Mitigation strategies can be to enter into hedge arrangements or long term PPAs. Change of legislation clauses may be required to protect against potential future regulatory changes.	

Performance

Reliability testing

The evolution of wind turbine models is rapid. An owner will want to ensure that the equipment performs to at least an acceptable minimum standard before the equipment is taken over. It is usual for equipment to undergo a full week of continuous testing under operational conditions, including some time at full power output and operating over the full range of conditions, to confirm the equipment can perform reliably and uninterrupted continuously for this period. Failure to achieve the result requires a restart of the test from time zero. Consideration needs to be given to the statistical average of the wind conditions which are likely to allow the tests to be completed.

Grid connection

Grid connection is generally one of the higher risk activities. The design and installation standards will require the input of specialist engineers. However, the timing of delivery of the infrastructure needs to be assessed and the delivery model around it with the appropriate allocation of obligations to control timing risk. Technical performance of the grid connection is also a very important element which needs to be considered within the Connection and Access Agreements. The actual performance requirements and testing and approvals process for grid performance needs to be identified prior to final execution of the agreements (at the very least the principles for determining the testing process).

Power curves

The electrical power output from the turbines needs to be guaranteed over the wind speed range. This is a critical test because the power/wind speed characteristic along with the wind resource assessment is used to predict the total energy from the wind farm. This has been used to assess the gross revenue for the wind farm. The test confirms that turbines are capable of delivering the expected power output over the wind speed range of operation. The technical requirements will involve identifying how many turbines are to be tested to form a representative sample and measurement of the wind speed for the testing. It is best that these requirements are explicitly stated in the contract documentation. These tests are usually carried out by an independent third party to an agreed process (normally stated in the contract conditions).

Noise curve guarantees

Noise emission from wind farms is an area for close attention. The noise emission from each turbine combines to provide an accumulated noise output from the wind farm. The total noise output of the wind farm will vary at any point around and within the wind farm and will be dependent on distances from turbines, topography (eg over a hill), wind speed and wind direction. The calculation of noise at external sensitive receptors (usually residences or property boundaries) is based on sophisticated modelling which includes the input of noise generated by each turbine at each wind speed. The performance of the turbines in respect to noise emissions is therefore critical for noise modelling purposes.

An additional factor in noise emissions from turbines is the emission of tonal sounds (eg a repetitive sound such as a hum from an electrical transformer). Specific technical standards apply (eg IEC 61400-11) for tonality and if tonality is found to exist, then a noise level penalty is applied to the measurement.

It is not unusual for an owner to require an absolute guarantee on noise emissions due to the critical nature of the performance. In some instances, if noise levels can be achieved by reducing the wind farm output, then the application of liquidated damages on the loss of power output may be an acceptable alternative to the owner. However the application of these damages should be at the discretion of the owner, with the absolute performance requirement being preferred.

Boundary line noise

The noise levels at the boundary of the wind farm which result from the accumulated emissions of each wind turbine is critical to ensure the DA conditions are able to be achieved. There are numerous factors which affect this noise level such as wind direction, terrain, ground conditions, vegetation conditions, etc. While most proponents attempt to seek guarantees from wind turbine EPC contractors for this performance, it is not unusual for this to be declined or heavily caveated by an EPC contractor. In most cases the risk ends up with the owner of which the owner has little control over, except for the performance obligations placed on the wind turbine provider for noise emissions of each turbine.

Availability guarantees

In addition to the reliability tests, an owner will want to ensure that the turbines are capable of operating for extended periods reliably. To achieve this, an availability guarantee is set. Normally this will require a target availability to be achieved during the defects liability period. This period can be as little as 12 months or up to five years. A reasonable period is considered to be 24 months. This guarantee is placed on the wind turbine equipment provider. Consideration will need to be given to any undue influence from the ongoing operations and maintenance after practical completion.

Rehabilitation

As most wind farms in Australia are built in rural areas that are currently carrying on agricultural activities, the landowners require that the developer takes the land back to its previous condition (excluding the roads and hard stand areas around the turbine foundations). This activity can be allocated to the contractor installing the roads and turbines or to a third party. Generally it takes at least a full season to restore the land to reasonable condition. For this reason, it is generally left to the primary contractor to clean up the site and revegetate but the ongoing monitoring and confirmation of the performance is left to the site operations and maintenance personnel.

Insurance Requirements

As a preamble to insurance, the time taken to finalise insurance policies cannot be underestimated. If the project is financed through external debt, then the extent of requirements by the project financier must be known and understood early in the development of the contracts.

Construction works

How the project is to be financed may influence the way that construction works insurance is brought onto the project. A project-financed development (particularly non recourse) will usually be arranged by the developer with specific requirements of the financier and their advisers. Construction works insurance can be taken out to cover the full extent of the project including all subcontractors and entities involved with the project. Project financiers may require special provisions to protect their lending position.

Public liability

Public liability is best placed to cover all participants involved with the site activities.

Marine cargo

Marine cargo will cover the shipment of components across the water between countries. If the project is being built by an EPC contractor, it is logical that the contractor takes out this insurance as it is the best control to manage the risks associated with the cargo (eg packing, distributing shipment of critical components, so the flow of work may not be completely stopped). However the policies held by the EPC contractors may not be satisfactory to financiers. A decision will be required to determine if the contractors' policy can be modified appropriately, or if the developer will need to take out a separate policy

Advanced loss of profits

Advanced loss of profits covers a situation where the project has an insurable event occur. The course of making good may set time at large, such that LDs are not recoverable or there are additional owners' costs and penalties from other third parties. Advanced loss of profits will cover the period of time from which project revenue was expected to flow, had the event not occurred. Advanced loss of profits, through separate policies, can be obtained to insure against events which have occurred on the construction insurance policy and for events which have occurred on the marine transit insurance policy.

Professional indemnity

Any design and specialist management for the project should be carried by the party with the risk. Insurance can be purchased and this is not cheap. In some cases, the EPC contractor will want to self-insure. In this case it is necessary to seek adequate assurances and back these up with indemnities.

Who carries the insurance?

Generally it is good practice for the owner/developer to carry the insurance. The owner has a complete understanding of the insurable events and policy limitations and the assurance of payment of the policy. It is generally found that the insurance policies put in place by the EPC firms are not adequate from a total project risk perspective and a number of EPC contractors may not be prepared to disclose their full policy details to the owner.

REVENUE

In the development wind projects, it is essential that prior to committing to the project an appropriate long-term offtake agreement with a credible counterparty is in place. The price available for the output from a project is dependent on the range of electricity and environmental products produced by the plant and the demand/supply position in the electricity market.

There is a range of market products available in the market and these are discussed below.

Electricity

- Larger wind farms – usually non-scheduled market generators. This allows self dispatch but may be affected by network issues.
- Sold "at the gate" on a whole of metered volume basis to minimise volume risk. Due to the intermittent nature of wind the output is non firm.
- The price will be impacted by the forward price for electricity which is influenced by the outlook for spot market prices.
- Impacted by loss factors (ie losses in the network due to location) – increase or decrease in pricing depending on loss factors.

Renewable Energy Certificates

- This is a mandated arrangement put in place at a federal level. The *Renewable Energy (Electricity) Act 2000* requires the generation of 9500 GWhrs by 2010.
- At present the REC market is oversupplied with sub $20 prices due to oversupply and the reluctance of the Federal Government to increase the mandated target volume.
- There is declining development activity at these prices.

Victorian Renewable Energy Certificates

- This is a recently mandated arrangement in Victoria which is to mirror the Australian Government MRET. The penalty is set at $43 but trading may not occur at this level. The scheme does not allow double dipping similar to MRET.
- Rules yet to be released.
- Retailers may develop their own projects in response.
- Other States yet to follow suit but they are keeping a watch on the development of the scheme.
- Some projects in Victoria are being developed in anticipation.

Green Power

- Voluntary scheme.
- Pricing offered at $3.00.
- No double dipping with RECs.

Capacity Credits

- Only in Western Australia.
- International Monetary Organisation (IMO) to source enough capacity credits to cover market's need for capacity.
- Wind farm allocated capacity credits by the IMO.
- Wind farm to apply each year for credits.
- Credits then sold to retailer in order to cover their customer load.

CONCLUSION

While the turbines and other components for a wind farm are mass produced, the complexity of a wind farm project and the development requirements none the less require the same amount of care and skill as any other industrial or building project. Development approvals will be required; stakeholders will require communication and management; contracting and delivery methods will need to be considered; financing arrangements will need to be in place; risks will be present and require management; insurances will need to be considered; revenue streams will need to be assured, and consideration will need to be given to the ongoing operation and maintenance.

The requisite skills and experience of varied experienced practitioners will be required at the various stages for the successful of development of a wind turbine project.

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