**Pakistan Environment Protection**
**February 2010**

# DRAFT

# Sectoral guidelines for Environmental Reports – Wind Power Projects

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# 1 INTRODUCTION

## 1.1 Scope of guidelines

Wind power projects harness natural wind and convert it into electrical energy. Over the past several decades, there have been steady improvements in technology and performance of wind power plants, and wind energy has become the world's fastest growing renewable electricity source. Wind power is proving increasingly to be cost competitive with thermal and nuclear power, but with virtually none of the environmental or social costs of these conventional sources.

Pakistan is blessed with abundant wind resources. Recent assessments and surveys have identified a number of areas with commercial potential -- along the 1,000 km coastline, and inland in Sindh, Balochistan, Punjab and Northern Areas. Pakistan's first commercial-scale wind power generation began in April 2009, from the 6 MW first phase of what is to be a 55 MW wind farm in Jhimpir, Thetta District, Sindh, within the 60 by 180 km Gharo-Keti Bandar "Wind Corridor". The Gharo Wind Corridor alone is estimated to have some 50,000 MW of wind power potential. Since the national target for renewable energy generation is 9,700 MW by year 2030, it is clear that wind power projects could play a significant role in the country's future energy development.

The Alternative Energy Development Board (AEDB) was established in 2004 to assess, promote, and facilitate the development of alternative or renewable energy resources such as wind power. The AEDB actively assists in the development and implementation of plans and projects, working with potential developers and with concerned authorities and provincial Governments.

To date, all utility-scale wind power development in Pakistan has focused on independent private producers, generally relying on foreign investment and imported technology and equipment, and exclusively concerned with on-shore wind power opportunities, specifically within the Gharo Corridor on lands already designated for wind power development by the Provincial Government of Sindh and the AEDB. As wind power becomes an established power generation alternative in Pakistan, a wider range of investors and locations are likely to become involved.

These guidelines deal with wind power plants, also known as wind farms, which will be defined as those producing electrical energy from wind primarily for commercial power generation. Wind power also has significant potential in Pakistan for providing power at the household and community or enterprise level – generally in units of 50kW or less.[1] There is currently no reason for these small wind developments to be subject to the national environmental assessment regulations.

The guidelines will assist proponents to identify the key environmental issues that need to be assessed as well as mitigation measures and alternatives that need to be considered in the actual environmental assessment.[2] Readers are advised not to apply a mechanistic approach based on the guidelines. Thoughtful consideration should be given to the proposal, its siting and the physical and cultural environment in which it is proposed, and no technique can replace this.

The environmental issues discussed in these guidelines are typical of the issues that a wind power plant development should address. The degree and relevance of the issues will vary from proposal to proposal. Environmental assessments for a given wind power project should only deal with issues relevant to the particular proposal and focus on key environmental issues.

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[1] Small scale wind power units are generally considered to be anything < 100kW in size.

[2] Throughout these guidelines, "environmental assessment" is used to encompass both Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) requirements as defined in the "Pakistan EIA Guidelines Package" described in Section 1.2.1.

## 1.2 Context of guidelines

### 1.2.1 The Pakistan EIA Guidelines Package

These Wind Power sectoral guidelines are part of a package of regulations and guidelines. They should be read in the context of the overall **EIA Guideline Package. This "Package" has been prepared by t**he Federal EPA in collaboration with other key stakeholders, including Provincial EPA's and Planning and Development Division from both the Federal Government and the provinces, other Agencies, NGO's representatives of Chambers of Commerce and Industry, and academics and consultants. The Package consists of comprehensive procedures and guidelines for environmental assessment in Pakistan. It is emphasized that the various guidelines should be read as a package; reliance on the sectoral guidelines alone will be inadequate.

The principal documents of the Pakistan EIA Guidelines Package are:

***Policies and Procedures for the filing, review and approval of environmental assessments*,** which sets out the key policy and procedural requirements. It contains a brief policy statement on the purpose of environmental assessment and the goal of sustainable development; requires that environmental assessment be integrated with feasibility studies; defines the jurisdiction of the Federal and Provincial EPA's; and lists the responsibilities of proponents and of the duties of Responsible Authorities. The *Policies and Procedures* also provides the schedules that determine whether a project requires either a full an Environmental Impact Assessment (EIA) – Schedule A -- or simply an Initial Environmental Examination (IEE) – Schedule B.

***Guidelines for the preparation and review of Environmental Reports*** is a longer and more descriptive document, which covers:

- The Initial Environmental report (scoping, alternatives, site selection, format of IEE)
- Assessing impacts (identification, analysis and prediction, baseline data, significance)
- Mitigation and impact management (and preparing an environmental management plan)
- Reporting (drafting style, main features, shortcoming, other forms of presentation)
- Review and decision-making (role, steps, remedial options, checks and balances)
- Monitoring and auditing (systematic follow up, purpose, effective data management)
- Project management (inter-disciplinary teams, programming & budgeting)

***Guidelines for public consultation***, which covers:

- Consultation, involvement and participation
- Stakeholders
- Techniques for public consultation (principles, levels of involvement, tools, building trust)
- Effective public consultation (planning, stages of EIA where consultation is appropriate)
- Consensus building and dispute resolution
- Facilitating involvement (including the poor, women, building community and NGO capacity)

***Guidelines for sensitive and critical areas***, which identifies sensitive and critical areas in Pakistan, in relation both to the natural environment and to cultural aspects.

***Pakistan environmental legislation and the National Environmental Quality Standards (NEQS),*** which is a reference document listing key environmental laws and regulations, and a complete listing of the NEQS.

**Detailed sectoral guidelines,** including Major Thermal Power Stations, Major Chemical and Manufacturing Plants, Industrial Estates, Housing Estates and New Town Development, Major Roads, Sewerage Schemes, and Oil and Gas Exploration and Production. These sectoral guidelines – including these guidelines for Wind Power -- follow a format with specific guidance and requirements on:

- A sector overview of the industry and processes
- Potential impacts on the environment
- Mitigation measures
- Monitoring and reporting
- Management and training
- Checklist of likely environmental impacts and mitigation measures

These reference documents are available online at: http://www.environment.gov.pk/info.htm.

### 1.2.2 Linkages between environmental impact assessment and other laws and procedures

In addition to the requirements for environmental assessment under the Environmental Act of 1997, there are a range of physical planning Acts, Ordinances and Regulations which may be relevant to wind power projects. Such measures for town plans and building controls can operate at Provincial, Municipal, District and even Local Council levels. Many of the considerations in the physical planning approval process are environmental in nature and are aimed at the same objectives as environmental assessment. It is important, therefore, that environmental assessment and physical planning requirements are both addressed during the planning process. The Alternative Energy Development Board (AEDB) has a mandate to assist the developers of wind and other renewable energy projects to work with these various levels of government and integrate wind power projects into local development planning. Project developers can obtain guidance and assistance on these matters from the AEDB.

Policy decisions, legislation and procedures in other areas will be relevant in considering and dealing with the environmental impacts for industrial estates. For wind power projects, the main considerations are in siting, so as to avoid ecologically or culturally sensitive areas, as well as noise or other localized disturbance to neighboring communities.

### 1.2.3 Economic and physical planning

#### National Economic Planning

A *Policy for Development of Renewable Energy for Power Generation* was approved by the federal Government in December 2006, and is to be updated in 2011. This policy establishes national targets for wind power development and for other forms of alternative energy, and also provides incentives to attract potential wind power developers and investors. The Alternative Energy Development Board (AEDB) has been given a central role in fulfilling these policies, and is working both with provincial governments and other concerned agencies, as well as with potential developers to encourage and facilitate the development of such projects.

#### Identifying Suitable Locations for Development

Wind farms, or wind power projects, are planned primarily on the basis of potential wind flow. While some of the data needed can be gleaned from satellite and ground monitoring, it is important to have time series of at least a full 12 months for each candidate location. Since wind power developments utilize turbines that are suspended 50-100 meters above the ground, the standard procedure is to construct a wind mast (tower) with automated recording equipment, and to monitor its readings on a continuous basis.

The AEDB has worked with the Pakistan Meteorological Department (PMD) and several international technical agencies to conduct nationwide assessments, and to establish an expanding network of wind masts in promising wind resource zones around the country.

Significant attention has been focused on the Gharo Wind Corridor. Assessments of local wind regimes have been conducted throughout the Gharo Corridor[3], and both a comprehensive baseline regional environmental assessment and generalized guidelines for assessment of wind projects within the Corridor have been published.[4] The AEDB is continuing to identify additional areas having good potential for wind power generation throughout the country.

**Developing Potential Sites**

The feasibility, design and development of any wind farm is likely to be undertaken by private developers in collaboration with the AEDB. The AEDB will guide and assist project developers in dealing with government agencies and procedures at Federal, Provincial, and local levels. This is a significant service to wind power project developers. In the Gharo Corridor, for example, the AEDB has already satisfied most local requirements for master planning, and can greatly facilitate permitting procedures for specific projects.

Feasibility (or pre-feasibility) studies need to consider economic, environmental and construction and operational issues before a private developer will decide whether to progress to design and construction. During feasibility stages initial environmental studies should be undertaken to ascertain if there are environmental factors that could affect the viability of the site, or which need to be taken into consideration and avoided or mitigated before approval or during final design.
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**Development Approvals**

While Environmental matters are legislated for at both Federal and Provincial level, physical planning is a Provincial function and the Provinces have developed their own Ordinances that allow for the creation of plans, planning controls and Building Regulations. In the case of wind power, the AEDB has both a mandate and capability to assist project developers to understand and comply properly with planning and permitting requirements at all levels of government. Ultimate responsibility for the wind farm project, however, rests with the owner, or the project developer. The project developer must assure that environmental and other studies meet the standards of the Provincial and National authorities that will review them.

**Community Engagement**

Wind power developers also need to take into consideration the communities that will be their project's neighbors. These are key stakeholders who are the most likely to be affected if a project negatively impacts the local environment, as well who stand to benefit from potential jobs or economic development surrounding the project. Again, AEDB will assist the project developer to initiate contacts with local community leaders and other principal stakeholders (local authorities, community associations and NGOs, landowners etc) to support the developer in designing and implementing a successful project. The developer should incorporate community consultation into its IEE.

### 1.2.4 Categorizations of Environmental Reports for Wind Power Projects

In light of the generally benign environmental nature of wind power projects but recognizing that each project site must be carefully assessed for its own potential issues, any onshore wind farm project of under 100 MW in design output will be considered as a Category B

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[3] Pakistan Meteorological Office, *An Investigation of Wind Power Potential at Gharo – Sindh,* Technical Report No. 6/2003 [http://www.pakmet.com.pk/wind/Wind_Project_files/gharo.pdf]

[4] *Regional Environmental Assessment Study of the Gharo Wind Corridor in Pakistan* and *Guidelines for Environmental Assessment of Wind Farms in the Gharo Wind Corridor – Pakistan.* Both studies were prepared by Taller de Ingeniería Ambiental, Eolic Partners, and Halcrow Pakistan (Pvt) Limited for the UNDP-GEF Wind Energy Project, and published in June 2009 [http://www.wep.org.pk]

project requiring only an IIE study, unless one or more of the conditions specified in the Table 1.1. is filled, in which case a full EIA study will be needed.

**Table 1.1** – Parameters for EIA and IEE studies of Wind Power Projects

| Category A - Environmental Impact Assessment | Category B - Initial Environmental Examination |
|---|---|
| Projects situated in environmentally sensitive areas. Areas within a radius of 1.0 km from the following sites<br>▪ Major Human communities (> 10 permanent inhabitants), industries and main transport network<br>▪ Notified protected areas buffer zone<br>▪ Wetlands of international importance including Ramsar sites<br>▪ Natural forests including reserve and protected forests e.g. mangrove and littoral areas<br>▪ Significant staging areas for migratory species<br>▪ Dumps and similar areas where birds are concentrated<br>▪ Notified Monuments and archeological sites, world heritage sites<br>▪ Any other site that will be considered by the Pakistan government in the scoping phase | Project areas not included in the environmentally sensitive areas |
| Distance is considered from the tip blade of turbines or/and transmission power lines associated.<br>These projects require a noise study. Additionally, when the communities are located within a 1.0 km radius, noise and shadow studies are required as part of the EIA. Wind farms projects within a 0.5 km radius from major communities will be avoided. | If minor human communities (< 10 permanent inhabitants) are within a 1.0 km radius, the project must carry out a noise study and a shadow study. Wind farms projects with a distance radius less than 0.3 km from minor communities will be avoided |

Also, any planned offshore wind power development will require a full EIA study.

## 2 SECTOR OVERVIEW OF THE WIND POWER INDUSTRY AND PROCESSES

### 2. 1 Wind Farms

Wind projects can be located at onshore or offshore locations. The primary factor in determining a site for a wind farm is the presence of a good wind resource. A wind resource use assessment is conducted to determine wind characteristics prior to siting and designing a wind farm. Other factors include financial cost of construction, access to transmission lines, environmental conditions, land use, and community support.

The major components of wind farms include the power system (i.e., turbine and generator) and associated facilities, which include electrical substations and transmission lines, and worker housing, if needed, and access roads. The size of the project and location will determine the type and size of these associated facilities.

The area required for a wind farm will vary with the number of turbines and their layout. Generally, more land are will be required if turbines are sited in parallel to the predominant wind direction rather than perpendicular to it. But the actual space required for the turbines and access roads is much less than the total project area. A wind farm comprised of 20 turbines might extend over an area of 1 square kilometer, with only about 1 percent of the land area occupied by the turbines and other structures. Wind turbines are spaced to maximize wind energy capture while minimizing the overall area needed. The primary factors to determine the spacing of the individual turbines are wind speed and turbulence. The turbines are typically arranged in bands or lines perpendicular to the prevailing wind direction or along the contours of ridges to obtain higher wind speeds.

The life cycle of a wind power project consists of wind resource use assessment, siting and design, manufacturing, transportation, construction, operation, maintenance, and decommissioning phases. Manufacture of the tower, turbines, generator, and other equipment is performed offsite by specialist providers. Transport takes into account the delivery of manufactured turbine components and construction materials to the wind farm site.

Activities typically associated with the construction phase include access road construction or upgrade, site preparation, transport of wind turbine components and installation of project components (e.g. anemometers, wind turbines, transformers, substations). The operation phase covers power generation, and maintenance of the turbines, including oil changes, lubrication, and transport for maintenance, usually by truck. Decommissioning activities depend on the proposed subsequent use of the site, but would typically consist of dismantling and removal of infrastructure (e.g. turbines, substations, roads), recovering other material such as lubricant oil, and reclamation of the project site, which may include re-vegetation for projects located onshore.

### 2.2 Turbines and Power Generation

Wind turbines today are generally three-bladed, with active stall control to adjust to fluctuating winds. The rated capacity (size) of each turbine may range from 1-5 MW, mounted on a tower that is a tapered cylinder in shape and usually made of steel. Towers range from 25 meters to more than 100 meters in height. The turbine consists of a foundation, tower, nacelle, rotor blades, rotor hub, and lights. The tower is bolted to a foundation, which is typically a thick slab of reinforced concrete measuring 15 or more meters across and 2 to 3 meters deep. In areas of poor ground conditions where there is not suitable bedrock, piled foundations as much as 30 meters depth may be needed.

Rotor blades are usually made of polyester resin, thermoplastics or epoxy-based resin, with carbon fiber as part of the composite structure. These materials have high strength, light weight, and flexibility. Typical rotors are 60 to 80 meters in diameter, or even 120 meters or more in offshore turbines. Most wind turbines start generating electricity at wind speeds of 3–

4 m/sec (10.8–14.4 km/hr), generate maximum power at speeds around 15 m/sec (54 km/hr), and shut down to prevent damage at around 25 m/sec (90 km/hr). Blade tip speed can be approximately 90m/s or 320 km/hr. At high wind speeds, stall and pitch controls will cause the turbine to cut off, to prevent it from spinning out of control – which could cause damage to the entire installation, including catastrophic failure of blades and the collapse of the turbine tower.

In a good location, a turbine will typically generate electricity 70 to 85 percent of the time. The amount of energy in the wind is proportional to the cube of the wind speed, so doubling the wind speed results in eight times the energy in the wind. The turbine's wind energy production does not change in the same proportion, however, but roughly with the square of the wind speed. The power generated by a wind turbine is generally at 700 volts, which must be stepped up to the voltage requirements of the local utility. This electricity is transmitted to a nearby substation that collects the energy from all the turbines of the wind farm and passes it to the electrical grid. The connection between a turbine transformer and the substation can be made using underground or aboveground transmission cables, and the turbine transformers can be connected independently to the substation, or interconnected to each other and then to the substation.

The operation of a wind energy project does not require permanent onsite staff. Maintenance activities are comprised of periodic turbine and rotor maintenance, lubrication of parts, full generator overhaul, and maintenance of electrical components. The design lifetime of a wind turbine is approximately 20 years, but in practice turbines may last longer.

### 2.3 Offshore Wind Farms

Offshore wind projects are more complex than onshore projects. The structural components (e.g. towers) are similar to their onshore counterparts, but with adaptations to the marine environment, including coating the metal parts to protect them from corrosion; using sealed nacelles; designing foundations/platforms and towers to cope with wind, wave, current, tide, and seabed interactions; and providing special access platforms for maintenance. The operation and maintenance activities include the transport of employees by ship and helicopter and occasional hardware retrofits. Special vessels and techniques for erecting turbines have been developed. In addition, individual turbine size is significantly larger, and turbines of 5 MW are typically used.

# 3 POTENTIAL IMPACTS ON THE ENVIRONMENT AND MITIGATION MEASURES

## 3.1 General

Generally speaking, wind power is the most environmentally friendly form of utility scale power generation presently available. Wind turbines need no fuel, so there are no environmental risks or degradation from the exploration, extraction, shipment, processing or disposal of fossil or nuclear fuels. During operation wind turbines generate no greenhouse gases, toxic metals, or other air pollutants. Furthermore, the area where the wind farm has been located can be returned to its original condition after decommissioning.

Nevertheless, the construction and operation of both onshore and offshore wind turbines can result in potential negative local environmental impacts on birds, bats, and cetaceans, and on local peoples, landscapes, land use, and the marine environment. The negative environmental effects from wind energy installations are generally much lower in intensity than those produced by conventional sources of electric power, but they still need to be assessed and mitigated. It is also important to note that badly sited or designed wind farms can have severe adverse effects on some environmental receptors. However, most of these impacts can be largely avoided or mitigated through proper siting, design, and consultation with the neighboring communities.

Negative impacts are considered in these guidelines in four distinct phases:

- site selection and design stage;
- construction stage;
- operations stage; and
- de-commissioning.

To assist proponents putting together an Environmental Report, impacts and mitigation are discussed in a systematic way under the four distinct project stages identified above. Appendix I is a checklist for proponents of the impacts and relevant mitigation, which are discussed item by item below, and which should be considered by a proponent when putting together an Environmental Report for a wind power project.

## 3.2 Site selection and project design issues

### 3.2.1 Existing land use and population

Onshore wind farms tend to be located in open landscapes – either flat or hilly terrain. Especially in upland sites, wind farms tend to be located in areas that are generally rocky or “barren”. But even though these areas may not support permanent habitation, local inhabitants may make seasonal use of the area, e.g. for grazing during wet seasons. There is sufficient clearance beneath the blades of modern wind turbines that allows cattle and other livestock to graze safely among them, and even for arable crops to be grown and harvested. It would normally be appropriate for such traditional uses to be allowed to continue.

Offshore wind farms are normally located in relatively shallow waters to enable the foundations to be constructed with relative ease, and because constructing wind turbines in deeper waters may not be cost effective.

Any resettlement of local people must be done in accordance with proper standards. The reader is referred to the *Draft National Resettlement Policy* of 2002, and to the Asian Development Bank's *Handbook on Resettlement: A Guide to Good Practice*[5] for a comprehensive discussion of the issues involved.

Wind farms around the world are seldom fenced off. Once a legal land lease has been established, no one should be expected to move into the wind farm, but automated security systems are generally installed and security guards may be maintained on the site. Safety issues may arise with public access to wind turbines (e.g. unauthorized climbing of the turbine) or to the wind farm substation. Therefore a developer may decide to fence the area immediately surrounding each turbine tower.

Installation of wind farms in a remote area will necessarily involve construction of an access road. This may open the area to exploitation by hunters, loggers, or prospectors.

**Management/Mitigation Measures:**

- Assure that land titles and leasing agreements are valid.
- Conduct public consultations, both to determine local land use, identify potential concerns of nearby residence, and to provide information to the community on the scope and nature of the project, and to inform them of potential options for safe use of the site (e.g. for grazing) as well as potential hazards.
- Fence the wind farm site, or individual turbines, to prohibit public access close to the turbine, without appropriate mitigation or compensation for any loss of land use by local communities;
- Prevent access to turbine tower ladders;
- Post information boards about public safety hazards and emergency contact information to assure direct access to the relevant government authorities and the wind farm managers.

It should also be noted that the Highway Ordinance defines requirements for set-backs of industrial development from public highways. Consent will be needed from the Highway Authority to construct or layout any means of access to or from a highway, or to erect any building upon land within 67 meters from the middle of the highway.[6]

### 3.2.2 Birds, bats, and environmentally sensitive and critical areas

Worldwide, habitat loss and degradation are the most serious threats to the conservation of birds and other wildlife. Pakistan is steward for a number of globally significant ecosystems; it straddles the Indus Flyway, and contains natural habitats ranging from the snow-covered ridges of the Hindu Kush to the arid plains of the Thar desert to the coastal mangroves of Sindh and Baluchistan.

A national system of protected areas has been established for the protection of endangered species, habitats, ecosystems, archeological sites, monuments, buildings, and other cultural heritage. The reader is referred to the *Guidelines for Sensitive and Critical Areas* for comprehensive guidance in assuring that sensitive or critical areas are not encroached upon or disturbed by wind farm development.

In general, wind turbines are not a hazard to wildlife. However, wind turbines can interfere with avifauna and may result in fatalities of both birds and bats wherever they are, particularly

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[5] Asian Development Bank, 1998, *Handbook on Resettlement: A Guide to Good Practice.* [http://www.adb.org/documents/handbooks/resettlement/default.asp]

[6] National Reference Manual on Planning & Infrastructure Standards 1986, Chapter 5.3, Ministry of Housing & Works Urban Affairs Division, Government of Pakistan.

if the wind farm I constructed in an inappropriate place where birds or bats congregate for any reason.

The Gharo Wind Corridor itself lies largely within the southern terminus of the Indus Flyway, but normal project planning, together with reference to the *Guidelines for Sensitive and Critical Areas* and the *Regional Environmental Assessment Study* for the Corridor[7] should enable developers of projects within the corridor to give due consideration to Kinjhar Lake and similar sensitive sites within the area.

Given the current undeveloped status of the sector, and the considerable wind resource potential, there is not a pressing need to develop commercial wind farms adjacent to or even within a kilometer or two of any of Pakistan's protected ecosystems. But the ecosystem and specific wildlife resources at any potential wind farm site should be investigated, including those species known to be on or near the site.

Coastal zones and shallow waters are especially significant for feeding, breeding, resting and migrating seabirds and marine species, including endangered sea turtles, so placement of turbines and the related construction activity may be of particular concern. Offshore, special consideration should be given to cetaceans, which are known to be subject to disturbance by wind turbines, both during construction and operation phases.

Buildings, towers, and antennae pose hazards to birds and bats worldwide. The presence of wind turbines, particularly during and just after construction, can displace birds from preferred habitats and reduce breeding success. Concern is warranted particularly in areas where birds concentrate, such as in wildlife refuges or shoreline feeding and nesting areas. On a global scale, recent literature reviews have found that wind farms are responsible for significantly fewer bird fatalities per gigawatt-hour (GWh) of electricity generated than from fossil-fueled power stations.[8] But each site must be considered as a unique case.

The main factors that determine the mortality of birds by collision in wind farms are landscape topography, direction and strength of local winds, turbine design characteristics and the specific spatial and height distribution of turbines. Every new wind farm project should, at an early stage of project planning, study the interaction between birds, their behaviour, and wind and topography at the precise location. This requires that data e collected for a proposed site over appropriate periods; surveys must consider migrating seasons as well as local bird population movements on a daily basis.

**Management Measures/Mitigation**

Prevention and control measures to address these potential impacts include the following:

- Conduct site selection to account for known migration pathways or areas where birds and bats are highly concentrated. Examples of high-concentration areas include wetlands, designated wildlife refuges, staging areas, rookeries, bat hibernation areas, roosts, ridges, river valleys, and riparian areas;
- Conduct surveys over an appropriate period over an annual seasonal cycle to assure that bird populations and movement around the site are understood;
- Sensitive and critical areas must be avoided;
- Offshore sites need to be assessed taking into account fish breeding habitats – this will require fisheries surveys during local fish breeding seasons to assess the breeding potential of the site.
- Configure turbine arrays to avoid potential avian mortality (e.g. group turbines rather than spread them widely or orient rows of turbines parallel to known bird movements);

[7] Taller de Ingeniería Ambiental, Eolic Partners, and Halcrow Pakistan (Pvt) Limited, *Regional Environmental Assessment Study of the Gharo Wind Corridor in Pakistan,* GEF Wind Energy Project, June 2009. [http://www.wep.org.pk].

[8] Benjamin K. Sovacool, "Avian mortality from wind power, fossil-fuel, and nuclear electricity", Energy Governance Program, Centre on Asia and Globalisation, Lee Kuan Yew School of Public Policy, National University of Singapore, 2009. [http://www.evwind.es/noticias.php?id_not=1236]

- Where uncommon or rare breeding species are present, construction work should be avoided during nesting season;
- Careful design of wind farms: siting turbines close together and grouping turbines to avoid an alignment perpendicular to main flight paths, and with corridors between clusters of wind turbines;
- Increase the visibility of towers and rotor blades to birds by using uniform colors and flashing rotor lights especially during migration;
- Install transmission cables underground, especially in sensitive areas;
- Implement appropriate storm water management measures to avoid creating small ponds which can attract birds and bats for feeding or nesting near the wind farm.
- Make overhead cables more visible using deflectors and avoiding use in areas of high bird concentrations, especially of species vulnerable to collision;
- Relocation of conflictive turbines;

If need be, operations can be halted or rotor speeds reduced during peak migration periods.

In sensitive locations, a biologist or ecologist should be present during construction. Since utility scale wind power is still new to Pakistan, there is an opportunity to learn from early project experience. At each wind farm, an environmental monitoring programme should be in place to monitor impacts on birds before, during, and after construction. This should include monitoring of bird mortality during construction and operation of the wind farm. Wind farm staff should be trained for this purpose.

These same general issues and mitigation measures apply to offshore wind power projects also.

### 3.2.3 Resources of historic or cultural significance

As described in Section 3.2.2 above, a national system of protected areas has been established for the protection of endangered species, habitats, ecosystems, archeological sites, monuments, buildings, and other cultural heritage. The reader is referred to the *Guidelines for Sensitive and Critical Areas* for comprehensive guidance in assuring that sensitive or critical areas are not encroached upon or disturbed by wind farm development.

Sites and areas of importance from an historic or cultural viewpoint need to be identified in the same way as is the case for sites in sensitive and critical areas. Significant sites such as those at Taxila and Mohenjo Daro should be fully protected and they should be particularly protected from any visual, noise, or other intrusions.

Again, there is no obvious reason for proponents of wind power projects to need to consider undertaking projects that would be adjacent to, or within 2 kilometers of a historic or cultural heritage site. Should such site be newly discovered in the course of planning or construction of a wind farm, it would be subject to established chance-find procedures within the *Guidelines.* For some sites of historic and/or cultural value, it may possible to set aside the land required to preserve the particular site and zone the land accordingly. The project design may then be adapted to include the historic or cultural resource.

### 3.2.4 Noise

**Onshore Wind Farms**

Sound emissions can be accurately measured using standardised acoustic equipment and methodologies. Therefore, compared to landscape and visual impacts, noise can be measured and predicted using standard methods..

Wind turbines produce noise when operating. The noise is generated primarily from mechanical and aerodynamic sources. Most current turbines designs require no gear boxes, thereby eliminating most of the mechanical noise typically of older designs.

The sound emissions of a wind turbine increase as the wind speed increases. However, the background noise will typically increase faster than the sound of the wind turbine, tending to mask the wind turbine noise in higher winds. At any given location, the noise within or around a wind farm can vary considerably depending on a number of factors including the layout of the wind farm, the particular model of turbines installed, the topography or shape of the land, the speed and direction of the wind and the background noise. Sound levels decrease as the distance from wind turbines increases.

Current designs of rotor blades with low rotational speed along with good noise insulation generator help limit noise emission. Wind turbine noise typically increases with increasing wind speed, as does the background noise levels. At low wind speeds, when background noise levels are low, the turbines do not operate. The critical period for noise impacts is likely to be at low wind speeds when turbines cut-in and when background noise levels are still relatively low.

Typically, at 200m the sound from a modern, medium-sized wind turbine would be about 45 dB (decibels), quieter than a typical indoor room where people are conducting a conversation. At 400m, the sound is generally comparable to that of leaves rustling in a gentle breeze. Such comparisons will vary with specific locations and conditions, but by keeping enough distance from settlements or built-up areas, noise pollution is avoided.

**Table 2.1:** Comparative Noise for Common Activities[9]

| **Source/Activity** | **Indicative noise level (dB)** |
|---|---|
| Threshold of hearing | 0 |
| Rural night-time background | 20-40 |
| 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 |

Low frequency noise (LFN), also known as infrasound, is used to describe sound energy in the region below about 200 Hz. LFN may cause distress and annoyance to sensitive people and has thus been widely analysed. But it is a subject complicated by difficulties in accurate measurement, and influences of surrounding landscape and other factors. Modern turbines with the rotor placed upwind produce very low levels of infrasound. Several recent expert panels and reviews of published assessments of infrasound from wind turbines generally conclude that infrasound is not a significant environmental concern. Nevertheless, anecdotal incidents– representing serious annoyance to the small numbers of people affected – continue to be reported. As with normally audible noise, the only sure solution appears to be to have a buffer distance of 1 or even 2 kilometers between an operating wind farm and the nearest community.

**Management/Mitigation Measures**

- Decreasing rotational speeds to under 65 m/s at the tip; and
- Using pitch control on upwind turbines, which permits the rotation of the blades along their long axis.
- Avoid siting wind farms within 2 kms of communities located downwind of the prevailing wind direction.

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[9] The Scottish Executive Development Department, *Planning Advice Note 45 (Revised 2002): Renewable Energy Technologies,* Edinburgh, Scotland, 2002. [http://www.scotland.gov.uk/Publications/2002/02/pan45/pan-45]

**Offshore  Wind Farms**

Offshore noise assessment must consider both audible noise and vibration. Both energy sources can be extremely destructive in an underwater environment as they impart a physical shock wave on receptors due to the incompressible nature of water (compared to air which is highly compressible and thus much of noise energy in the air is attenuated rapidly). Underwater noise and vibration may be transmitted for many kilometers.

Offshore noise is primarily associated with construction activities. There is increasing evidence from research in Europe that underwater noise sources can cause significant damage and harm to many marine species, particularly cetaceans and species with swim bladders. Therefore if the wind farm is proposed in an area where there are significant concentrations of vulnerable species (e.g. dolphins) at a particular time of year, then construction involving piling or other noisy activities should avoid such seasonal appearances.

Noise generated during the *operation* of the offshore wind farms appears far less likely to displace marine fish and mammals from the project site. However, activities associated with the installation or removal of offshore wind turbines and subsurface cables may result in temporary displacement of fish, marine mammals, sea turtles, and birds. This displacement may result from direct auditory or vibratory disturbance impacts or indirectly from increased sediment levels in the water column due to disturbance of the seabed.

Management/mitigation measures include:

- Employ noise mitigation measures for all construction activities and avoid highly energetic activities underwater;
- Deploy craft around the construction site to monitor for cetaceans or significant schools of fish in the area before any noisy underwater activity commences to avoid fish kills or damage/death to marine mammals and turtles;
- Employ a ‘soft start’ procedure for pile-driving activities to help prevent exposure of fish, marine mammals, and sea turtles to damaging sound levels and provide them with an opportunity to leave the area; and
- Use hydraulic jet plowing technology for the installation of cables, which is considered the least environmentally damaging alternative when compared to traditional technologies.

### 3.2.5 Visual Impacts

Wind farms with a number of turbines become dominant points on the landscape.  Within about 2 km, the turbines are perceived as large scale and the movement of blades is obvious; beyond 2 km, they become less visually dominant, but in many circumstances they are still obviously visible from distances of 10 km or more.  Also, most turbines and towers are fitted with aviation warning lights, which at nighttime are also visible from a great distance.

Landscape perception and visual impact are by nature subjective and change over time and location.  In Pakistan, they are likely to be perceived favorably, as a positive sign of new energy and development in the region – at least if the local population has access to electricity themselves.  From international experience, there is no evidence to suggest that the presence of wind farms either onshore or offshore poses a serious negative impact on tourism. But the merits of adding huge metal turbines to a landscape is hotly contested by those who perceive them as unwelcome visual intrusions into the natural or rural landscape. Typical wind farm sites in Pakistan are “barren lands” in otherwise undeveloped areas.   Initial reactions are likely to be positive. But if wind farms eventually become commonplace or intrude on landscapes of particular cultural significance, their aesthetics will likely also become an issue for at least some Pakistani people.

**Shadow Flicker and Blade Glint**

Sunshine passing through rotating rotor blades will cast moving shadows. Under specific and readily predictable conditions, this can cause a flickering effect that can be annoying if seen through a window or reflected from a television or video screen. This effect, called either shadow casting or shadow flicker, is restricted to within a distance of 1 kilometer – or about 10 times the length of the turbine blades – and occurs for only a brief period, usually totaling only a few minutes within a day, and only under very specific lighting conditions. Software able to accurately predict potential shadow flicker is readily available, so the problem can be avoided by positioning of wind turbines, and maintaining a minimum distance of 1 kilometer from dwellings.

Similar to shadow flicker, blade or tower glint occurs when the sun strikes a rotor blade or the tower at a particular orientation. The reflection of sunlight off the rotor blade may be angled toward nearby residences or roadways. All modern wind turbine blades are coated for low reflectivity, so blade glint is now a muted effect at worst. But, like shadow flicker, it is easily modeled for a given wind farm design, and siting of the turbines at least 1 km away from the nearest residence should eliminate this potential issue.

**Management Measures/Mitigation**

Mitigation measures to prevent and/or minimize visual impact from wind farms on landscape can be summarised as follows[10]:

- Design wind farm according to the peculiarities of the site and with sensitivity to the surrounding landscape – this should include the results of a digital terrain model looking at zones of visual impact such as is typically used in wind projects worldwide. Such models demonstrate the potential impact and assist the developer in micro-siting specific turbines to minimize visual impacts on receptors;
- Select wind turbine design (tower, colour) according to landscape characteristics or matching the sky (light gray or pale blue);
- Selection of neutral colour and anti-reflective paint for towers and blades, and avoid lettering insignia or graphics on the turbines;
- Lights for aviation should be used only where and when needed;
- Minimize presence of ancillary structures on the site by avoiding fencing, minimizing roads, burying intraproject power lines, and removing inoperative turbines;
- Avoid steep slopes, implement erosion measures, and promptly revegetate any cleared land with native species only; and
- Maintain uniform size and design of turbines (e.g. direction of rotation, type of turbine and tower, and height).

Specific prevention and control measures to address shadow flicker and blade glint include;:

- At the design stage, use commercially available modeling software to identify any potential glitter or flicker problems from the planned wind farm layout, and adjust turbine placement if there appear to be potential problems;
- Design specifications should include use of wind turbine towers and blades with non-reflective surfaces or coatings;
- Site the wind farm at least 1 km from the nearest residence.
- If necessary, a particular turbine can be turned off for a certain number of hours.

[10] Brusa and Lanfranconi, Brusa, A., Lanfranconi, C.(2007), *Guidelines for realization of wind plants and their integration in the territory* [http://colorsofthecity.org/allfiles2/501_Ewec2006fullpaper.pdf]

### 3.2.6 Other Potential Impacts

**Electromagnetic interference (EMI)**

Electromagnetic interference (EMI) is any type of interference that disrupts, degrades or interferes with the effective performance of electronic devices or of telecommunications and broadcast networks. Wind turbines, generally of older design, can potentially disrupt electromagnetic signals used in telecommunications, navigation and radar services. Modern blades are typically made of synthetic materials which have a minimal impact on the transmission of electromagnetic radiation. The electrical system is not usually a problem for telecommunications because interference can be eliminated with proper nacelle insulation and good maintenance.

Interference on communication systems is considered to be negligible because it can be avoided by careful wind farm design. Therefore, possible disruption to radar or telecommunications from EMI should be considered during the design phases of each wind project

**Aircraft and Marine Navigation Safety**

Wind turbine blade tips, at their highest point, may reach well over 100 meters in height. If located near airports or known flight paths, a wind farm may impact aircraft safety directly through potential collision or alteration of flight paths. Similarly, if located near ports, harbors, or known shipping lanes, an offshore wind turbine may impact shipping safety through collision or alteration of vessel traffic.

**Management/Mitigation Measures**

During the design phase of the wind farm, collision risk analyses, and risk analyses of the wind farm's interference with aviation equipment should be conducted. Safety features (e.g., ability to switch off all turbines during emergency conditions, emergency plans and protocols) should also be incorporated at the design phase of the project.

In addition, project developers should:

- Consult with air and marine regulatory traffic authorities before installation, in accordance with air and marine traffic safety regulations;
- Use anticollision lighting and marking systems on towers and blades; and
- Avoid siting wind farms close to airports or ports and within known flight path envelopes or shipping lanes.

**Blade Failure**

A failure in the rotor blade can result in the 'throwing' of a rotor blade from the wind turbine. The risk of blade throw is extremely low, and may be further mitigated through the following measures:

- Establish a safety setback such that no buildings or populated areas lie within the possible trajectory range of the blade. This safety setback range is unlikely to exceed 300 meters, although the range can vary with the size, shape, weight, and speed of the rotor, and with the height of the turbine;[12,13]
- Equip wind turbines with vibration sensors that can react to any imbalance in the rotor blades and shut down the turbine if necessary;
- Regularly maintain the wind turbine; and
- Use warning signs to alert the public of risk.

## 3.3 Construction Impacts

The construction phase is the time when impacts on workers, land and water, and the surrounding community are generally greatest.

Construction activities for wind energy projects typically include land clearing for site preparation and access routes; excavation, blasting, and filling; developing borrow and fill areas; earth moving, dewatering, dredging and/or impounding streams and other water bodies, transportation of supply materials and fuels; construction of foundations involving excavations and placement of concrete; operating cranes for unloading and installation of equipment; and commissioning of new equipment.

Construction activities generating noise include:

- Excavation activities for turbine and building footings including drill and blasting;
- Excavation of cable trenches;
- Crane activities associated with tower erection;
- Transportation movements associated with delivery of machine and construction material;
- Concrete batch plant; and
- Construction of access roads, including use of rock breakers and blasting.

Much of this noise is unavoidable, although its effect on surrounding communities will be minimized if the wind farm has been situated a kilometer or more away. All local ordinances controlling time of allowable work, health and safety, and construction standards need to be adhered to.

Earth moving, vehicle traffic, and other construction activities in dry, rocky areas may be expected to stir up dust and particulates. Dust suppression methods should be implemented accordingly.

### 3.3.1 Occupational Health and Safety

Occupational health and safety hazards during the construction, operation, and decommissioning of onshore and offshore wind energy projects are generally similar to those for most large industrial facilities and infrastructure projects. They include physical hazards such as working in confined spaces, working with rotating machinery, and falling objects. Project managers should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero -- especially accidents that could result in lost work time, different levels of disability, or even fatalities.

The construction work for a wind farm may extend over a number of months. Throughout this period, access to the construction needs to be strictly controlled. Just like any other industrial facility, wind power plants should establish an on-going occupational health and safety monitoring program, and maintain a record of occurrences and accidents.

There will also be on-going safety hazards inherent in normal power generation operations and maintenance of the wind turbines, lines, and substations. While the likelihood of any single hazard is small, they must all be prepared for in advance. These hazards include:

- Accidental or controlled fires;
- Falling turbine blade or damaged turbine
- Damage to turbine components due to high winds;
- Turbine blade failure;
- Vehicle accidents;
- Exposure to high voltage;
- Accidents while accessing the wind farm; and
- Accidental access of public inside the turbine or on the turbine tower.

Lightning strikes are also a threat to wind turbines. While there are as yet no universal industry standards, contemporary wind turbine and tower designs include arrestors to attract and channel lightning strikes away from electronic equipment and structural elements. A lightning strike is potentially devastating to a wind turbine, so this is a critical aspect of tower and turbine design. This is an architectural design issue, and should be addressed by relevant authorities during engineering design review.

Fire extinguishers (both powder and liquid type) must be made available during the assembling and installation phase of sub-station transformers and wind turbine generators. An adequate supply of spill prevention, fire-suppression, and emergency response equipment needs to be kept onsite at all times during the construction phase, as well as when maintenance is performed on the turbines. And worker and site personnel need to be trained in hazardous materials handling and emergency response procedures.

Emergency plans need to be in place in case of accidents or equipment failure. Electronic and mechanical control systems should continuously monitor key operating parameters, and there should be automatic fail-safes built into the software controlling the turbines. Monitoring staff at an operating wind farm should be equipped with properly functioning communications devices, enabling them to transmit the information of any incident or accident without delay to concerned agencies. Similarly, local authorities should have direct 24/7 access to wind farm managers, and signs should be posted at the wind farm site to provide emergency contact numbers.

### Working at Heights

Working at heights is necessary during installation and assembly of wind tower components and general maintenance activities during operations. Prevention and control of hazards associated with working at heights include:

- Prior to undertaking work, test structure for integrity;
- Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers;
- Establish safety procedures for 100 percent fall protection. The fall-protection system should be appropriate for the tower structure and movements to be undertaken including ascent, descent, and moving from point to point;
- Install fixtures on tower components to facilitate the use of fall protection systems;
- Provide workers with an adequate work-positioning system. Connectors on positioning systems must be compatible with the tower components to which they are attached;
- Ensure that hoisting equipment is properly rated and maintained and that hoist operators are properly trained;
- Safety belts should be of not less than 15.8 mm (5/8 inch) two in one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibres become evident;
- When operating power tools at height, workers should use a second (backup) safety strap;
- Signs and other obstructions should be removed from poles or structures prior to undertaking work;
- An approved tool bag should be used for raising or lowering tools or materials to workers on elevated structures; and
- Avoid conducting tower installation or maintenance work during poor weather conditions and especially where there is a risk of lightning strikes.

### Working over Water

Offshore wind farms add the additional hazard of working over open water. Prevention and control measures associated with working over open water include the basic principles described for working at heights, as above, together with the following:

- Conduct a risk assessment and management plan for water, wind, and weather conditions before conducting work;
- Use approved buoyancy equipment (e.g. life jackets, vests, floating lines, ring buoys) when workers are over, or adjacent to, water where there is a drowning hazard;
- Train workers to avoid salt spray and contact with waves;
- Provide appropriate marine vessels and qualified boat operators and emergency personnel.

### 3.3.2 Land Clearance and Drainage

Clearing of the entire site will not be necessary. Bush and shrub vegetations will only be removed along surveyed rights-of-way, in foundation sites and work areas. The existing vegetation may be covered by the fill material and piling up of construction material storage. An access road may be required, or an already available road may require broadening in order to accommodate heavy traffic that is expected for delivery of equipment. This may lead to a potential destruction of flora mostly shrubs and bushes to be cleared for the purpose.

During construction of access roads it is possible that small rural water supplies could be disrupted. This is most likely to occur in hilly terrain where springs might provide water for domestic or livestock use. An inappropriately placed access track could cause pollution of the source (from silty runoff entering a spring discharge point or watercourse) or the loss of the spring if it is coming from shallow groundwater flow. To mitigate against this all access routes should be surveyed for water features within 250m of the routes (in relatively highly populated rural areas this corridor might have to increase to say 500m if there is evidence that water supplies are obtained from vulnerable sources – evidence for this situation would be the presence of small spring fed sources that have variable flow rates through the year). Water features must be shown on maps included in the environmental reports – and where they serve a local population the potential disruption to users needs to be assessed and mitigated against. As a minimum no newly constructed access track should be permitted within 50m of any spring or water supply point.

The main factors to bear in mind are as follows:

1. Increased noise from operation of construction equipment and trucks;
2. Dust, stirred up by traffic and construction activity;
3. Relationship of any new access roads to local water flows and drainage, and drainage impacts from any widening of existing access roads
4. Run off erosion during rains from unprotected excavated areas resulting in excessive soil erosion;
5. Possible local flooding from de-watering of excavations, flushing of pipes or increased run-off during heavy rainfall. etc.;
6. Loss or degradation of vegetation from unnecessary removal or mechanical damage;
7. Any unavoidable loss of large trees, especially in arid areas;

**Management Measures/Mitigation**

- Proper dust suppression methods should be followed during the construction phase of the project. Regular watering of construction sites and access tracks should be carried out to control fugitive dust emissions.
- Cleared vegetation for the developmental purposes should not be simply disposed of by burning unless no other reasonable and practicable disposal methods are available. If burning does occur, it should be undertaken in such a way so as to prevent emissions from causing an environmental nuisance.
- No large trees should be removed in arid areas unless there is absolutely no alternative. Any significant trees removed should be replaced in a ratio of 5 to 1 and the developer should be responsible for producing a proposed planting plan showing how the re-vegetation works would be completed and maintained for at least five years after construction is over.
- Topsoil must be properly stripped and stored for future use and not illegally removed from the site. Areas can be protected by temporary fencing and limitation of access

for heavy machinery and material storage. This will help protect vegetation and avoid exposing larger areas to erosion and run off risks.

Erosion control plans should be established to provide for:

- temporary silt fencing;
- temporary ponding or silt trap basins;
- short term seeding or mulching of exposed soil areas, particularly on sloping land; and
- limitation of access for heavy machinery and the storage of materials to avoid soil compaction.

### 3.3.3 Delivery of Components and Equipment

Many of the components for a wind power plant are long and heavy. In Sindh, for projects in the Gharo Corridor, the port of Qasim will generally be used to import turbine components such as generators, blades and hubs. Consultation with local authorities should be undertaken to assure that available roads have the infrastructure in place to accommodate the expected traffic. Limited upgrading of existing roads and bridges may be required along the designated route. This upgrading may involve road widening and realignment in some sections. During construction phase of the project, there will be an increase in vehicle movements on public roads.

**Management Measures/Mitigation**

- The delivery route to the wind farm site needs to be assessed – specifically to insure adequate load bearing capacity of all bridges and drainage works along the route;
- On public roads, delivery of oversize and heavy components or construction materials should be coordinated with the local road and police authorities. They have responsibility for road safety, including temporary reductions of speed limits marks on the sides of the roads to minimize the chances of any fatal accident.
- Within the wind farm, a main trunk road through the site and a series of spur ways to individual turbines is suggested to regulate the traffic and minimize the operational loss to environment.

### 3.3.4 Management of Wastes

During the construction phase, a significant volume of plastic, cardboard and timber packaging wastes are likely to be generated from the supply of equipment to the site. Other solid wastes are likely to include general construction materials and packaging. In addition, used oil, filter and grease cartridges, lubrication containers and other equipment maintenance products need to be collected and disposed of. All of these solid and liquid wastes need to be either recycled or properly disposed of at the nearest government-approved waste disposing facility.

**Management Measures/Mitigation**

- Recyclable waste should be sold to recycling contractors.
- Biodegradable waste should be buried at an appropriate place.
- Left-over construction material should be sold to other users.
- Residual wastes should be transported to the nearest approved landfill or waste disposal facility, or otherwise disposed of in accordance with provincial and local regulations.

### 3.3.4 Socioeconomic Impacts

Even if construction camps are located on the wind farm site itself, there will likely be considerable interaction with the nearest neighboring settlement or community. Where the host community is small, there is potential for stress. A “boom town” condition can result with significant negative effect on the existing community infrastructure such as hospitals, transport, police, and so forth. Similarly, an influx of workers from other localities or regions may disrupt local social and cultural values, as well as living patterns of residents. The purchasing power of the new workers can distort local markets, and lead to economic dislocation for the original community.

These issues should be considered in advance in consultation with local authorities. Wind farm developers should pro-actively seek to employ local labor wherever appropriate, and may want to consider opportunities to contribute to community projects or infrastructure as good corporate social practice.

## 3.4 Decommissioning

Decommissioning activities are primarily to dismantle and remove project infrastructure, and to rehabilitate the site to its original condition or in preparation for a designated use. Since commercial wind farms have been operating worldwide only since about 1980, there is relatively little experience to date with wind project de-commissioning. In most countries, however, the wind farm developer is required to establish a bond to cover potential de-commissioning costs at the end of the project's useful life – or in the event of financial or other business failure of the venture during construction or operation. It is also likely that at the end of its planned lifetime a wind farm will be "repowered" or have its turbines and other equipment replaces with improved, more modern equipment.

In the case of eventual decommissioning, the project owner will need to adhere to applicable government permits or regulations. The decommissioning and restoration process includes:

- removal of above-ground structures (turbines, transformers, overhead collection lines, and the substation,);
- removal of below-ground structures (turbine foundations);
- restoration of topsoil;
- re-vegetation and seeding; and
- implementation of a monitoring and remediation period – usually of at least two years.

.
Wind farm components – turbines, nacelles, towers, lines and substations – include valuable materials for salvage or recycling. so the owner will wish to inventory, market and sell or re-use what he can. Any remaining scrap materials must be transported and disposed of in accord with local laws.

### Offshore

Prior to decommissioning of an offshore wind farm, a biological survey or assessment should be made. The physical presence of the submarine portion of the wind turbine tower and the foundation may provide a new substrate (artificial reef habitat), resulting in the colonization of coral and other marine life, thereby creating new refuge habitat or feeding areas.[7] Therefore It may be desirable to leave all or a substantial portion of the original structure in place.

# 4. MONITORING AND TRAINING

## 4.1 Monitoring

As with other industrial or energy sector facilities, an on-going monitoring and reporting program should provide the following information:

- actual impacts from the project;
- early warning information of unacceptable environmental conditions; and
- actual impacts compared to predicted impacts.

The project developer should maintain a file and respond to written concerns about environmental impacts of the project on an ongoing basis. Upon completion of the construction phase, the site should be inspected to ensure that any areas that require re-seeding, restoration of surface drainage, erosion control, or other reclamation measures have been adequately addressed..

The agencies concerned will be:

- Pakistan EPA, and the relevant provincial EPA;
- the Provincial office responsible for occupational health and safety measures on the estate and particularly the factory inspector; and
- local government services responsible for safety measures and emergency procedures.

Monitoring for wind power plants should begin before design and construction to determine *baseline conditions*. Baseline conditions are distinct from before plant conditions in that they refer to monitoring *before* the construction phase begins. It is important that baseline conditions are determined at the earliest possible time i.e. prior to the design stage of the project. Data should be collected with respect to each significant impact identified and it will then be possible to confirm predicted impacts and ensure mitigation measures are acceptable. Baseline data collection methodology is covered in Section 3.4 of the *Guidelines for the Preparation and Review of Environmental Reports*.

The length of monitoring during construction and operation phases will depend on the environmental resource that is being affected and the expected duration of the impact.
Wind energy facilities do not normally generate process emissions and effluents during their operation. Nevertheless, developers and operators of wind power should be familiar with the *National Environmental Quality Standards* (NEQS) for effluents and gaseous emissions. The requirements represent the basic minimum standards that apply to all projects.

Since one of the primary concerns for wind power projects worldwide has been their impact on bird and bat populations, wind farm managers in Pakistan are urged establish and maintain a program of monitoring for bird and bat mortality, and maintain it for at least two years. This should provide a base of information for future decision-making concerning siting and mitigation measures for future wind power development in the country.

Specific parameters for monitoring and reporting to appropriate authorities during construction and operational phases should be clearly identified in the Environmental Management Plan prepared as part of the project's IEE and/or EIA .

## 4.2 Training

The working force responsible for both design and operation of the wind farm should be aware of their role in promoting an environmental friendly technology. Training, through lectures, assigned readings, and short courses play a significant role in establishing and maintaining a successful infrastructure investment.

The environmental trainings will help enhance awareness level of the proposed wind farm staff and contractor staff on all matters relating to the environment. Federal and Provincial environmental agencies should be requested to collaborate in the training, and may contribute both materials and trainers. These trainings will ensure that the requirements of the Pakistan EPA and other concerned agencies are clearly understood and followed by the wind farm staff and contractors throughout the project period.

It is suggested that these training programs be planned before start of the construction phase to inculcate environmental awareness among the employees -- including principal project design staff. The scope of the training will cover environmental guidelines, general environmental and social awareness, waste disposal and other topics relevant to design, construction, and operation activities, in order to minimize the environmental as well as social concerns of the project. This training should be provided to all staff to be engaged in the project development from initial stage to later stages.

Environmental training may be required for:

- general impact assessment concepts
- methodologies
- monitoring theory and methods
- data collection and analysis
- and pollution control strategies.

If possible, the project's design and operational staff should be involved in the environmental assessment study for the project. This will ensure an understanding of the issues and findings of the assessment. In particular, staff workers must have an understanding of the rationale for the recommended mitigation and monitoring that they will be implementing. Training should be given to the technical staff and supervisory staff, including the power plant engineers and managers.

Staff training in management and enforcement of standard operating procedures, as well as health and safety procedures will be required to minimize environmental and health and safety impacts of the plant once it is in operation.

## REFERENCES

This document, and other guidelines in the series, rely heavily on existing sources, including the "Pakistan EIA Guidelines Package" described in Section 1.2.1, and also:

- *ADB Environmental Assessment Guidelines* ,2003[11]
- World Bank *Environmental Assessment Sourcebook, 1999*[12]
- *National Reference Manual on Planning and Infrastructure Standards,* 1986[13]

For information on wind power project development in Pakistan, refer to the Alternative Energy Development Board (AEDB), at http://www.aedb.com. Additional information on Pakistan's wind power resources is available from the Pakistan Meteorological Office, http://www.pakmet.com.pk. The United Nations Development Program (UNDP) and Global Environment Facility (GEF), have worked with the AEDB to promote wind power development in Pakistan. The reader is referred in particular to the series of reports prepared by Taller de Ingeniería Ambiental, Eolic Partners, and Halcrow Pakistan (Pvt) Limited for the UNDP-GEF Wind Energy Project, published in June 2009. The series includes four titles:

- *Environment & Socio-Economic Baseline Report*
- *Cumulative Impact Assessment & Alternatives*
- *Environmental Management Plan*
- *Guidelines for Environmental Assessment of Wind Farms in the Gharo Wind Corridor-Pakistan*

These publications are available at http://www.wep.org.pk.

For comprehensive information on wind power technology, siting, and environmental impacts, there are several key reference sources:

International Finance Corporation (IFC), Environmental Health, and Safety Guidelines for Wind Energy, April 2007
[http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines]

American Wind Energy Association, *Wind Energy Siting Handbook,* prepared by Tetra Tech EC, Inc. and Nixon Peabody LLP, Washington, DC, February 2008.
[http://www.awea.org/sitinghandbook/downloads/AWEA_Siting_Handbook_Feb2008.pdf]

*Wind Energy – The Facts* is a comprehensive web-based reference developed by a consortium led by the European Wind Energy Association (EWEA), updated in 2009.
[http://www.wind-energy-the-facts.org/]

The Australian Clean Energy Council (ACEC), among others, has developed a set of comprehensive and current reviews of health and noise impacts of wind turbines. see: "Wind turbine & low frequency noise fact sheets",
[http://www.cleanenergycouncil.org.au/cec/technologies/wind/turbinefactsheets]

Additional key topic-specific references are cited in the footnotes of these guidelines.

[11] Asian Development Bank, Environmental Assessment Guidelines, 2003. Available at: http://www.adb.org/documents/guidelines/environmental_assessment/environmental_assessment_guidelines.pdf.
[12] Available at http://go.worldbank.org/LLF3CMS1I0
[13] http://www.environment.gov.pk/eia_pdf/k_Industrial%20_October_.pdf – see Appendix A.

## Checklist of Environmental Parameters for Wind Power Projects APPENDIX I

| Actions Affecting Environmental Resources and Values | Damages to Environment | Recommended Feasible Measures |
|---|---|---|
| A. Problems related to site selection and design phase | A. Depends on Nature of Problem | A. Depends on Nature of Problem - Reject site if Inappropriate |
| 1. Displacement of existing land use e.g. grazing | 1. Loss of economic resource | 1. Public consultations; establish procedure for safe grazing |
| 2. Disturbance or destruction of sensitive areas | 2. Loss of natural habitat | 2. Avoid siting in vicinity of sensitive areas |
| 3. Impact on birds and bats | 3. Impact on species | 3. Avoid siting in local or migratory flyways; use appropriate design techniques |
| 4. Disturbance or destruction of cultural resources | 4. Impact on historical and cultural values | 4. Avoid siting in vicinity of cultural sites. |
| 5. Noise | 5. Nuisance to local residents | 5. Maintain a setback of >1 km from nearest inhabitants |
| 6. Visual impacts, including shadow flicker and blade glint | 6. Loss or impairment of landscape values; nuisance | 6. Maintain a setback of >1 km from nearest inhabitants |
| 7. Electromagnetic interference | 7. Disturbance to telecommunications | 7. Use contemporary standard turbine designs |
| 8. Aircraft and navigation safety | 8. Disturbance to radar and communications | 8. Proper siting and use of contemporary standard turbine designs |

| | | |
|---|---|---|
| B. Problems During Construction Stage | B. Unnecessary Environmental Damages | B. Careful Construction Planning and Monitoring |
| 1. Risks to workers from accident | 1. Injuries to workers and nearby residents | 1. Commitment to Health and Safety; careful construction planning, training, and monitoring |
| 2. Silt runoff from construction work | 2. Soil erosion with damage to property and aesthetic values | 2. Erosion control planning and careful monitoring |
| 3. Dust disturbance during construction | 3. Health and nuisance to workers and vicinity | 3. Watering and other control measures |
| 4. Local flooding from | 4. Local flooding | 4. Careful construction |

| | | |
|---|---|---|
| run-off during storms | damages | planning and monitoring |
| 5. Loss/degradation of vegetation from mechanical damage | 5. Loss of vegetation, forest and habitat in general | 5. Careful construction planning and monitoring |
| 5. Loss of time and fuel and accidents | 5. Traffic congestion and blocking of access | 5. Careful construction planning/monitoring, and coordination with authorities |
| C. Problem During Operation Stage | C. Depends on Nature of Problem | C. Careful O&M, plus Operation Stage Monitoring |
| 1. Pollution, health hazards & nuisance | 1. Damage to workers & adjoining residents | 1. Competent O&M |
| 2. Occupational health inadequacies | 2. Damage to worker safety and health | 2. Occupational health plan plus monitoring |
| 3. Inadequate O&M performance | 3. Damage to worker safety | 3. Occupational health plan plus monitoring |
| 4. Blade throw | 4. Damage to structures or people | 4. Proper siting, layout, and maintenance |

**Illustrative examples of potential negative impacts Vs specific mitigation measures** **APPENDIX I**

| **Potential Negative Impacts** | **Specific Mitigation Measures** |
|---|---|
| 1. Human population/ traditional use displacement | • Avoid sites with habitation or intensive use<br>• Public consultation<br>• Accommodate traditional grazing<br>• Involve affected parties in any resettlement planning and program |
| 2. Disturbance of threatened or Endangered Species or Habitat | • Locate wind farm away from known habitat of endangered species and critical ecological reserves |
| 3. Disturbance of Avian and Bat Species or Habitat | • Identify bird and bat species, habitat (year-round and seasonal), and migration pathways in region, and locating wind farm away from these areas<br>• Site wind masts and turbines away from flyways<br>• Install deflectors, lights, and other visible features |
| 4. archaeological and historical resources | • identify archaeological and historical resources through a desktop analysis and avoid siting in vicinity of designated resources |
| 5. Land development constraints | • Identify land development constraints that may influence the location of the wind farm. These can be both regulated constraints as well as guidelines suggested by the community or developer.<br>Some of these constraints include:<br>□ Noise limits (state and local standards)<br>□ Setback requirements<br>□ Floodplain issues<br>□ Height restrictions<br>□ Zoning constraints |
| 6. Telecommunications interference | • preliminary investigation of known telecommunications transmissions and microwave paths. and impingement |
| 7. Aviation considerations | • This includes the identification of known airports, landing strips and other aviation considerations. |
| 9. Visual/Aesthetic Considerations - To the extent possible, at this early stage, visually sensitive areas, such as designated scenic vistas, parks, and residences may be identified.<br>Visual impact on historical, archeological, and cultural resources and on landscapes | • Restore or create similar vegetation or habitats<br>Select alternative site or site layout<br>• Construct visual buffers (e.g., plant trees) |

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