Chapter 4
Specific Permitting Considerations and Strategies

This chapter examines some of the specific considerations that may need to be addressed in permitting wind projects, whether they are large wind facilities which sell power to utilities, one or more turbines constructed to support the existing transmission and distribution system, or single turbines to provide power to a single user. Strategies and tips for dealing with these potential issues should be considered in the context of the guidelines and principles presented in Chapter 3. In planning for potential wind energy development or reviewing a proposed project, permitting considerations may include impacts and benefits associated with any or all of the following:

- Land use
- Noise
- Birds and other biological resources
- Visual resources
- Soil erosion and water quality
- Public health and safety
- Cultural and paleontological resources
- Socioeconomics, public services, and infrastructure
- Solid and hazardous wastes
- Air quality and climate

Not all permitting considerations apply to every wind project. The relative importance of these issues and appropriate methods for addressing them will vary for each project because of differences in topography, land use, environmental resources, community concerns, agency experience and expertise, permitting processes, project economics, state or local energy policies, electrical system needs and characteristics, local attitudes and politics.

Many tradeoffs and costs are associated with strategies to address these considerations. It is important to remember that impact mitigation strategies often have some economic cost associated with them, and that tradeoffs may have to be made, both in terms of project economics and in terms of addressing different impacts. The siting process involves balancing issues and making tradeoffs, both among the various impacts and between the benefits and costs associated with impact mitigation measures. Permitting agencies must strike a balance between what is required to make a project publicly acceptable and the costs these requirements and conditions impose on the developer and the project. This chapter begins with a brief discussion about making such tradeoffs.

The issue-specific discussions which follow focus on considerations unique to wind facilities. Because wind facilities are land "intrusive" rather than land "intensive," and because they most typically are located in rural or remote areas, impacts tend to be somewhat different from those of most other electric generation facilities. Wind facilities may be "pioneer" developments in previously undeveloped areas. These factors create unique implications for land use, visual, noise, biological, and cultural considerations in particular. Many agencies have found that visual resources, noise, safety, and avian collisions are the most common concerns encountered in wind facility permitting. However, even significant concerns about a project may be resolved through planning, education, minor project changes, appropriate mitigation measures, and active compliance monitoring.

Following the discussion of each specific area of consideration, several possible strategies are presented. Strategies offered in this chapter include both technical or physical strategies for mitigating potential impacts, regulatory tools, and suggestions on how these may be incorporated into the permitting process outlined in Chapter 3. Many of these strategies are based on insights from individuals who have been involved in permitting, constructing, operating, or monitoring wind facilities. Each section concludes with a few "tips" for permitting agencies or project developers to consider when proposing or reviewing wind facilities.

Further Resources. Appendix A lists resources, annotated for those who wish to learn more about a particular topic. Appendix B presents a matrix of the wind-related ordinances adopted by local agencies in California, and Appendix C provides a more detailed discussion of noise measurement techniques and considerations.

TRADEOFFS

Siting a wind facility requires making tradeoffs among impacts and mitigation strategies and also in terms of the decision-making process itself. *Process tradeoffs* pertain to decisions about how the permitting process is structured and carried out. Creating a process that provides for better and more defensible

decisions lessens the likelihood of delays and litigation, thus reducing the risk and overall cost of the permitting process. However, developing and designing such a process requires a commitment of government resources and may be viewed by developers as unnecessary regulation, rather than as an improvement. *Impact and mitigation tradeoffs* concern choices which must be made in balancing the benefits of proposed impact mitigation strategies against the costs of such measures, and also in weighing the relative importance of different impacts.

Process Tradeoffs

The three major process tradeoffs are made in:

1) committing to develop a formal wind siting process;

2) deciding when and to what extent to involve the public; and

3) establishing a time frame within which the overall process should reach a decision.

Review of statutory authority to develop a siting process. If there is a reasonable likelihood that wind energy development will occur in a particular area, the appropriate government body should review its legal authority for permitting wind facilities (or for making other decisions that could be used to permit wind facilities) and decide if it is adequate for and suited to wind facility siting. There are benefits to being able to clearly specify what is expected of wind developers and how decisions are to be made on wind facilities, but seeking specific statutory authority also takes time and a commitment of resources on the part of an agency. Some in the industry do not want to see specific statutory authority developed for wind facilities, and view such statutes as creating new and unnecessary regulations. Others see specifying the rules of the game for all participants as a way to lower the likelihood of litigation and otherwise reduce the level of uncertainty and risk associated with the permitting process. Public officials need to consider these factors in reviewing the statutory authority of the decision-making agency (or agencies) and deciding whether any wind-specific statutes or ordinances need to be passed.

Public involvement. Successful siting processes for other types of generating facilities have been moving in the direction of increasing public involvement and involving the public earlier in the decision-making process. Yet there is a tradeoff to be made in opting for early public involvement. To the extent that involving the public early provides a chance to resolve problems before the final decision is made, the likelihood of litigation and associated costly delays can be reduced. However, public involvement should be tailored to the magnitude of the project, its likely impacts on public resources, and the level of public concern. Extensive public involvement may not be warranted if there are no significant public issues or concerns; however, it generally is wise to tell people about a proposed project as early as possible.

Reasonable process time frame. The permitting process should provide adequate time to identify impacts, to develop appropriate mitigation measures, and to inform and involve the public. On the other hand, the longer the permitting process, the higher the cost to developers (and, indirectly, to the public). Public officials need to balance the need for adequate time to identify and address issues with the need for timely decision-making. For example, if it appears a proposed wind facility might have an impact on migratory birds, the permitting process should provide time to gather information on these birds when they are in the area. To proceed without adequate information only to encounter problems after a facility has been sited may mean having to delay operations while mitigation measures are developed and implemented. In many cases, such measures could have been incorporated more cheaply and effectively during design and construction. Similarly, while there is a cost associated with providing time for public involvement, not providing adequate time for comment and resolution of issues may result in these issues being taken up in the courts. This can significantly delay a project and impose substantial costs on developers, no matter what the outcome of the legal process.

Impact and Mitigation Tradeoffs

There are two major types of tradeoffs associated with impacts and mitigation. The first is the tradeoff between the benefit and the *cost* of mitigation measures and the second involves *tradeoffs among different impacts.*

Mitigation costs. The most important tradeoff to keep in mind when considering impacts and

mitigation strategies is their effect on the cost of the project. The front-end costs associated with mitigation measures are of particular concern to developers. Permitting agencies must respond to the public's concern that project impacts be kept to an acceptable level, and generally have a legal obligation to mitigate significant environmental impacts. But agencies also have substantial latitude in deciding what constitutes appropriate mitigation. Because each project is different, there is no simple formula for reaching this decision. In general, decision-makers need to make sure that:

- the impacts are significant enough to warrant mitigation;
- the mitigation measure is appropriate and likely to be effective;
- the permitting agency has a legal basis for imposing the cost of mitigation on the developer; and that
- developers are asked to spend only what is necessary to mitigate the impact.

If the cost of mitigating a significant impact—e.g., a threat to an endangered species—proves to be cost-prohibitive, the best decision may be to deny the permit for the facility. (Indeed, in such a situation the developer may wish to withdraw the application before spending additional monies in what could be an expensive and perhaps futile process.)

Tradeoffs among impacts. As this chapter indicates, wind energy projects have the potential to create a variety of impacts. Strategies for mitigating certain of these impacts may exacerbate other impacts. For example, painting wind turbine generators to blend in with the background will reduce the facility's visual impact, but may create an unacceptable public safety hazard if there is an airport nearby. Fencing generator areas to prohibit public access for safety's sake may interfere with wildlife grazing and migration. Weighing and balancing these impacts is the job of the permitting agency and its decision-makers. In some cases (air traffic safety vs. visual impact), the choice may be clear; in other cases, a general consensus about how to balance competing impacts may emerge from public participation in the permitting process.

There are also cases in which the same mitigation measure addresses a number of likely impacts. Adequate buffer zones (distance from the edge of the development to the turbines) reduce noise and visual impacts, create safety zones, and generally lessen the likelihood of any impacts on (or from) neighboring properties. Reducing the need for roads within a wind development preserves habitat or cropland while reducing project infrastructure costs, erosion and water quality problems and visual impacts. An expensive mitigation measure such as installing underground electrical wires, which may not be justified on the basis of its effect on a single impact, may prove to be cost-justified when all the impacts the measure would mitigate are taken into account. In any case, decision-makers are encouraged to look for opportunities to reduce multiple impacts with a single mitigation measure.

LAND USE

Many federal, state, and local agencies prepare and implement plans or policies that set goals and guidelines for the development and use of lands within their jurisdiction. These are intended to ensure that there is sufficient land available for various uses, that adjacent uses are compatible and that there is an orderly transition between differing types of uses. In evaluating whether a proposed project is both consistent with existing plans, goals and policies and compatible with existing and planned adjacent uses, permitting agencies often consider a project's potential to change the overall character of the surrounding area, disrupt established communities, or physically intrude upon the landscape. Where land use plans and policies exist, they often are critical to the outcome of local or state-level permitting decisions. However, a proposed project which is inconsistent or incompatible with existing land use plans and policies may still be approved if the permitting agency adopts a variance or makes a finding of overriding considerations.

In most land use plans and policies, electrical generating facilities are allowed in areas that have been designated for manufacturing and industrial purposes. Conventional coal, oil or natural gas fired power plants are characterized by some combination of industrial buildings, tall smokestacks, tanks and pipe lines, electrical switchyards and the associated industrial sounds and smells. They tend to be land intensive, compressing a variety of industrial equipment and structures into a relatively small space. Their structural requirements and visual characteristics often blend in with the facilities in industrial areas and are buffered from other quieter or more sensitive land uses. Some land use plans also allow

electrical generating facilities to be located in rural or relatively undeveloped areas—close to fuel supplies, water resources, transmission lines or transportation systems needed for operation, or away from population centers if they pose a potential health or safety concern.

Land Use Considerations

Unlike most power plants, wind generation projects are land intrusive rather than land intensive. On a megawatt (MW) output basis, the land required for a wind project exceeds the amount of land required for most other energy technologies. However, while wind facilities may extend over a large geographic area and have a broad area of influence, the physical project "footprint" covers a relatively small portion of that land. A 50 MW wind facility, for example, may occupy a 1,500-acre site; but the amount of land actually occupied by the facilities described in Chapter 2 may only be three to five percent of the total acreage, leaving the rest available for other compatible uses. (See Figures 8 and 9.)

Because wind generation is limited to areas where weather patterns provide a relatively long season of strong and consistent wind resources, the development of wind projects in the United States has occurred primarily in rural and relatively open areas. These lands are often used for agriculture, grazing, recreation, open space, scenic areas, wildlife habitat, forest management, and seasonal flood storage. Wind development typically is compatible with the agricultural or grazing use of a site. Although these uses may be interrupted during construction, only intensive agricultural uses may be reduced or modified during project operation.

Development of wind projects may affect other uses on or adjacent to a site, or in the surrounding region. Some parks and recreational uses that emphasize wilderness values and reserves dedicated to the protection of wildlife—particularly birds—may not be compatible with nearby wind developments. Other uses, such as open space preservation, growth management or non-wilderness recreation facilities, may be compatible depending on setbacks, the nature of on-site development, and the effect on resources of regional importance. The variables that may determine land use impacts include: the site's topography; the size, number, output and spacing of the turbines; the location and design of roads; whether accessory facilities are consolidated or dispersed; and whether the electric lines are overhead or underground.

Land Use Strategies

A wide range of actions may be taken to ensure that wind projects are consistent and compatible with most existing and planned land uses. Many of these involve the layout and design of the wind project. For example, where wind development is located in, near, or adjacent to recreational or scenic open space uses, some permitting agencies have established requirements to "soften" the industrial nature of the projects.

Figure 8. Wind energy is compatible with cattle grazing in California's Altamont Pass. Photo courtesy of the American Wind Energy Association (AWEA).

Figure 9. Unconcerned with the rotating blades, a Pronghorn Antelope grazes near these wind turbines in Fort Davis, Texas. Photo courtesy of AWEA.

These include:

- selecting equipment with minimal structural supports such as guy wires;
- requiring maintenance facilities to be off-site;
- requiring electrical collection lines to be placed underground;
- consolidating equipment on the turbine tower or foundation pad;
- consolidating structures within a wind area, project, or region;
- requiring use of the most efficient or larger turbines to minimize the number of turbines required to achieve a specific level of electrical output;
- selecting turbine spacing and types to reduce the density of machines and avoid the appearance of "wind walls" (see Figure 10, bottom, page 42);
- use of roadless construction and maintenance techniques to reduce temporary and permanent land loss;
- restricting most vehicle travel to existing access roads;
- limiting the number of new access roads, width of new roads, and avoiding or minimizing cut and fill; and
- limiting placement of turbines and transmission towers in areas with steep, open topography to minimize cut and fill.

In determining whether to apply these impact mitigation strategies to a project, permitting agencies should consider the costs associated with a proposed strategy, type and level of impact, the reasonableness of the actions, the land use objectives of the community, the significance of any potential land use inconsistency or incompatibility, and the available alternatives.

Many of these techniques have been adopted in European countries. Wind projects in Europe are often located in rural and agricultural areas, but they have tended to be single dispersed units or relatively small clusters. In several countries, the wind turbines have been placed on dikes or levees, along coastal beaches and jetties, or off-shore. Turbines located in agricultural use areas are sited to minimize disturbance to cropping patterns, and the necessary permanent infrastructure and services are consolidated within a single right-of-way placed on field edges, in hedgerows or along farm roads. Often no access roads are constructed, and construction or periodic maintenance is done with moveable cushioned mats or grating. Thus the footprint of the project is further reduced, and minimal land is lost to production.

Other land use strategies associated with development of wind generation sites in the United States include the use of buffer zones and setbacks to separate wind projects from other potentially sensitive or incompatible land uses. The extent of this separation varies depending on an area's land use objectives and other concerns such as aesthetics, noise or safety (see *VISUAL RESOURCES, NOISE*, and *PUBLIC HEALTH AND SAFETY*, below). Some local land use agencies in California have adopted ordinances establishing setbacks which range from two to four times the height of the wind turbine or a minimum of 500 to 1,200 feet from any off-site residence or residential area. A few local agencies have established setbacks from all property lines that range from 1.25 to four times the height of the wind turbine or a minimum of 500 feet from exterior property boundaries (see Appendix B). The State of Minnesota has similarly established minimum setbacks of 500 feet from occupied dwellings.

"Wind access buffers" and other measures to protect wind rights have also been established for some projects. In Minnesota a wind access buffer of not less than five rotor diameters has been required to ensure that wind projects on adjoining properties do not interfere with each other. On some projects, the resource managers for adjacent properties have established lease or permit conditions so that wind project development on one parcel does not block use of the wind resource on the adjacent parcels.

Planning for wind development. If wind resources exist within a jurisdiction, land use planning agencies are encouraged to consider these resources early in their planning and policy activities. Some agencies, recognizing the potential for wind generation, have prepared maps of the potential wind resource areas showing information such as wind speed and duration, topographic features, site

Wind Development and Open Space

Some communities have used the planned development of wind generation projects to control the growth of communities and infrastructure by precluding or discouraging urban or residential land uses in the vicinity of the wind resources. Wind development can help maintain a feeling of open space in areas where urbanization is spreading, or provide a buffer to protect agricultural land uses.

characteristics, existing roads and facilities, potentially sensitive land uses, and environmental considerations. Agencies should also review existing land use plans, zoning designations and policies to provide appropriate, up-front guidance to developers on where and how to locate wind projects so that they are consistent with existing land uses and the environment. These same actions will ensure that other development activities do not preclude the construction and operation of electric generation in prime wind resource areas. Some agencies have formally identified wind resource areas (WRAs) in their plans to facilitate permitting and development of wind generation in preferred locations.

Coordinating to resolve land use issues. As emphasized in Chapter 3, close coordination can benefit all the project stakeholders—including utilities, agencies, the public, and developers—by ensuring continuity, consistency, and certainty. Wind project developers should contact the land use agency or agencies regarding their plans and policies very early in the project planning process. To effectively resolve potential land use concerns, all the agencies involved in reviewing and making land use decisions on proposed wind generation projects must coordinate and communicate with each other in a timely manner throughout the lifetime of the project. It is also essential that staff within various offices or departments of an individual agency work together during the permitting process so that any conditions or requirements are consistent and are monitored throughout the lifetime of the project.

Finally, land use agencies should recognize that individual landowners play a critical role in the proposed use of a site for a wind project. Like the wind developers, landowners need to know how their property fits into the larger picture of developing available wind resources before negotiating private wind leases and easements. If landowners are aware of agencies' policies and requirements, they can ensure that their agreements with wind project developers are compatible, and that all their concerns are or will be addressed. These concerns will vary with the interests of the landowners and may include:

- road location, paving, and maintenance;
- construction of new fencing, gates or livestock facilities;
- security and public access controls;
- dust and erosion controls;
- topsoil retention;
- fire protection;
- interference with agricultural practices;
- electric line placements;
- future planting rights; and
- site restoration.

Few of these topics typically appear in leases to date. However, it is important for agencies to realize that contract or lease conditions required by land owners or managers may be relevant to subsequent permit conditions. While agreements with individual property owners are negotiated outside the permitting process, they should be completed in anticipation of the permit so there are no loose ends or conflicts which may delay permitting or construction of a project.

Land Use Tips

Stakeholders

1) *BE FLEXIBLE - Don't get locked in to development plans, permit conditions or other requirements before you understand the big picture.*

Permitting Agencies

1) *Look at the land use relationships and objectives for an entire wind resource area. Early knowledge of concerns and planning is crucial to reducing potentially incompatible uses.*

2) *Consider the potential impacts of both wind and non-wind project development in the wind resource area before development projects are proposed, and develop a plan for the area that minimizes land use conflicts.*

3) *With input from wind developers, resource agencies and the community, develop specific land use classifications, zones, policies and development guidelines for wind projects in advance of permit applications.*

4) *Review each individual wind project design for compatibility with existing and other planned land uses in the wind resource area.*

5) *Ensure that all the stakeholders fully understand the entire project (construction, operation, and decommissioning) in order to address and resolve potential land use issues.*

6) *Consider landowner agreements before making specific permit conditions. (If it isn't a problem, don't fix it!)*

Project Developers

1) *Contact agencies, property-owners and other stakeholders early to identify potentially sensitive land uses and issues.*

2) *Learn the rules that govern where and how a wind project may be developed.*

3) *Review and resolve land use compatibility issues before leasing the land.*

4) *Design the project site layout for efficient use of the land and consolidate necessary infrastructure requirements wherever possible.*

5) *Beware of potential conflicts between lease provisions and permitting agency conditions for project development.*

NOISE

Noise is defined as any unwanted sound. Concerns depend on the level of intensity, frequency, frequency distribution and pattern of the noise source; background noise levels; terrain between emitter and receptor; and the nature of the noise receptors. The effects of noise on people can be classified into three general categories:

1) Subjective effects of annoyance, nuisance, dissatisfaction.

2) Interference with activities such as speech, sleep and learning.

3) Physiological effects such as anxiety, tinnitus, or hearing loss.

The sound levels associated with environmental noise, in almost every case, produce effects only in the first two categories. Workers in industrial plants and around aircraft can experience noise effects in the last category. Whether a noise is objectionable will vary depending on the type of noise (tonal, broadband, low frequency, or impulsive) and the circumstances and sensitivity of the individual (or receptor) who hears it. Primarily because of the wide variation in the levels of individual tolerance for noise, there is no completely satisfactory way to measure the subjective effects of noise, or of the corresponding reactions of annoyance and dissatisfaction.

A somewhat more detailed discussion of noise measurement, including the development of acoustic standards specifically designed for measuring noise from wind turbine generators, can be found in Appendix C.

Noise Considerations

Operating noise produced by wind facilities is considerably different in level and nature than that generated by most power plants, which are typical of large industrial facilities. Wind facilities are often located in rural or remote areas with a corresponding ambient noise character. While noise may be a concern to persons living near wind electric generators, much of the noise emitted by the turbines is masked by the ambient or background noise of the wind itself. Noise of all kinds falls off sharply with distance.

Noise produced by wind turbines has diminished as the technology has improved. Early model turbines are generally noisier than most new and larger models. As blade airfoils have become more efficient, more of the wind is converted into rotational torque and less into acoustic noise. Under most conditions, modern turbines are quiet. However, some components used for rotor speed control, braking, and electronics or fluid cooling can create noise even in a well-designed turbine.

Noise generated by wind projects. Construction noise generated during site development and restoration (blasting foundation holes and air lift turbine installation, maintenance, and turbine removal) is not typical of wind project operation. The largest impacts from construction noises are likely if they coincide with bird mating or nesting seasons, or if the activities take place during off-hours when people living near the site are trying to sleep. During project operation, wind systems may make noise in two ways (see box, next page, for noise definitions).

1) Aerodynamic, including:

   - broadband
   - impulsive noises, and
   - low frequency; and

2) Mechanical, including:

   - tonal noises.

Aerodynamic noise is made by the flow of air over and past the blades. It increases with rotor speed. This broadband noise typically is the largest component of a turbine noise measurement. When the turbine is not turning due to lack of sufficient wind, no noise is emitted. When the wind is turbulent, the blades also can make low frequency noise as they are buffeted by changing winds. If the wind is disturbed by flow around or through a tower before hitting the blades as in a downwind turbine design, the blade will emit an impulsive noise every time it passes through the “wind shadow” of the tower. Such low frequency noise is not adequately represented by A-weighted measurements.

Unlike variable speed turbines which turn faster with increasing wind speed, fixed rotor speed

Types of Noise Which May be Generated by Wind Turbine Operation

Broadband Noise. *Noise characterized by a continuous distribution of sound pressure with frequencies greater than 100 Hertz (Hz). Often caused by the interaction of wind turbine blades with atmospheric turbulence. Also described as a characteristic "swishing" or "whooshing" sound.*

Impulsive Noise. *Short acoustic impulses or thumping sounds that vary in amplitude as a function of time. Caused by the interaction of wind turbine blades with disturbed air flow around the tower of a downwind machine (one on which the rotor faces away from the prevailing wind).*

Low Frequency Noise. *Noise with frequencies in the range from 20 Hz to 100 Hz associated mostly with older-model downwind turbines. Caused when wind turbine blades encounter localized flow deficiencies due to the flow around a tower, wakes shed from the other blades, etc. (At its worst, such noise has been described as "an ongoing debilitating sound" that can cause structural vibration.)*

Tonal Noise. *Noise at discrete frequencies. Caused by wind turbine mechanical components such as meshing gears, by non-linear boundary layer instabilities interacting with a rotor blade surface, by vortex shedding from a blunt blade trailing edge, or unstable shear flows over holes or slits.*

turbines come up to full rotational speed at wind speeds just above the wind speed (typically nine or 10 mph) at which the turbine "cuts in," or begins producing electricity. (Some turbines are capable of both modes of operation or have two rotor speeds.) Because lower background noise conditions make turbine noises more noticeable, fixed speed turbines are most likely to have noticeable aerodynamic noise just above cut-in wind speeds before the wind-induced background noise rises enough to mask the noise of the turbine.

Mechanical noises can be produced by a variety of components of the wind system. Depending on the condition of the gear faces and bearings, gearboxes can be significant sources of tonal noise. Generator bearings can become defective, and open frame generators may include integral cooling fans. Some yaw drives may cause irregular, creaking, impulsive noises which may resonate throughout the turbine structure. Yaw and drive train brakes that are abruptly fully-activated also may cause noises that resonate in the structure. High speed cooling fans may be used in the nacelle for cooling power electronics, hydraulic or gearbox fluids, or at ground level with power electronics subsystems. Normal wear and tear, poor design or adjustment, or lack of preventive maintenance of any of these components may cause them to become noisy over a turbine's life.

Variables affecting noise receptors. In general, the more the new noise level exceeds the ambient noise level, or the more the new tonal characteristics differ from the prior, the less acceptable the new noise will be to exposed individuals. Many variables can affect the noise produced by a wind project and its effect on receptors. Wind directions, speeds and turbulence levels are important variables. Site topography and vegetation affect turbulence and background noise levels. Intervening topography and atmospheric conditions (boundary layers, temperature gradients, air absorption, etc.) affect propagation from source to receptor.

If a receptor is in a location where the wind is normally slower than at the wind turbine, the background masking noise there will be lower too. This is unlikely in flat terrain. However, in undulating terrain, residences often are built in the depressions (for protection from the wind) where the masking noise will be lower. Given the relationship between turbine noise and wind speed, a turbine is more likely to be heard at twice the normal distance at a wind-sheltered location.

The background noise, even in otherwise very quiet locations, is strongly determined by the wind speed and nearby obstacles which induce turbulence. When wind speed rises, so does the broadband background noise which masks aerodynamic noise from a turbine's rotor. However, if the turbine's

noise is tonal (probably from a mechanical source) it is much more noticeable at the same relative loudness level because it is not broadband, but composed of one or more distinct tones.

Predicting and measuring noise levels. Accurate pre-project estimates of noise emissions and levels at receptors are very difficult to make, and do not lend themselves to easy comparison with absolute levels in permitting standards. Predicting and measuring noise from a proposed project involves many complicating factors, some of which are not controllable or easily reproducible. Turbine noise measurements taken under certain conditions at one site may not be representative of noise emissions by the same turbine at another site. If the original noise measurements have been adequately documented, the predictions may be partially applicable elsewhere, but the measurements may not reflect conditions encountered at another site or show the turbine's greatest apparent noise level. For instance, winds from one direction may be more steady (stable), and produce less measured low frequency noise than more turbulent winds from another direction. Prior noise measurements may not have been made at wind speeds just above cut-in, which (because broadband noise readily blends with background noise) is when the potential for objectionable noise is greatest. A-weighted measurements are effective for measuring this noise and may be transferable from another site but may not reflect levels at receptors due to propagation differences.

Noise Strategies

In the course of permitting wind projects, many permitting agencies conduct a noise analysis to estimate:

- whether the facility can be constructed and operated in compliance with any and all applicable guidelines or local ordinances;
- whether any potentially significant noise impacts may result from the construction and operation of the facility; and if so,
- whether feasible mitigation measures can be employed to minimize or eliminate significant noise impacts resulting from construction and operation of the facility.

These agencies have dealt with potential noise concerns by predicting and measuring noise levels, establishing noise standards, requiring noise setbacks, establishing zoning restrictions, and making turbine modifications. To effectively handle noise concerns that may arise after permitting, some agencies have implemented a noise complaint and investigation process.

Predicting and measuring noise. Turbine noise studies should include separate measurements of low frequency and A-weighted noise levels across a range of wind speeds (including near cut-in) and turbulence conditions, distances from the turbine, and locations of the receptor relative to wind direction. Appendix C cites two proposed noise measurement techniques specific to wind energy systems.

Background noise measurements could be made at representative dwellings up to one quarter mile in flat terrain and one half mile in uneven terrain from the nearest turbine. Potential receptors at relatively less windy or quieter locations than the project should be emphasized. This information could be required by the permit, provided it is within the agency's authority to do so. It must be borne in mind, however, that it is almost impossible to predict accurately noises that may occur under the full range of possible conditions.

Noise standards. Although no federal noise regulations exist, the US Environmental Protection Agency (EPA) has promulgated noise guidelines. Similarly, most states do not have noise regulations. Many local governments however, have enacted noise ordinances to manage community noise levels. The noise limits specified in such ordinances are typically applied to acute noise sources and specify a maximum permissible noise level. They are commonly enforced by the police, but may be enforced by an agency which issues development permits.

Imposing a fixed level noise standard may not prevent noise complaints. This is due to the changing relative level of broadband turbine noise with changes in background noise levels. If tonal noises are present, higher levels of broadband background noise are needed to effectively mask the tone(s). Also, the impact of noise depends on what people are doing: lower levels of noise will be objectionable during sleeping hours than during the day.

Noise Tips

For Permitting Agencies

1) *Do not expect the final word on noise levels and their acceptance until the project has operated under all the usual wind conditions at the site.*

2) *If applying noise standards, make sure they provide a relative noise standard for broadband noise. This will account for the relative background noise level changes caused by wind. For example, the threshold for taking action to reduce noise levels could be when wind facilities exceed the background noise by 5 to 8 decibels. Use of this standard would require taking preconstruction background noise surveys at nearby residences. Be cautious, however, about using noise standards designed for other purposes since they are not likely to do a good job for all the types of noise that may be present, i.e., broadband, tonal, low frequency and impulsive noises.*

3) *Pay particular attention to potential noise concerns at residences in wind-sheltered locations that are close to wind project areas.*

4) *Establish a noise complaint and evaluation process (see box next page).*

For Project Developers

1) *Design projects with adequate setbacks from dwelling units, especially where the dwelling unit is in a relatively less windy or quieter location than the turbine(s). Assume that residents who like the wind system may some day be replaced by others who are annoyed by any noise.*

2) *Consider making extra efforts to prevent problems by upgrading all turbines installed where residences are nearby. Use extra sound insulation and baffled nacelles, soft equipment mounts and braking systems, and low speed fans for cooling. Fans could be relocated to the nacelles. Equipment needing cooling could be relocated to where it is cooled by the wind. Blade trailing edges could be made sharp. Avoid locating marginally noisy turbines in projects with nearby residences.*

Some states have lower noise standards during night hours.

Noise setbacks. Because noise diminishes with distance, adequate setbacks are the primary tool for preventing noise problems. An appropriate distance may range between 1,000 feet and one-half mile. (An exception may be made for the turbine's owner.) If the only applicable scale for assessing compliance with a noise standard is the dB(A) scale, more liberal setbacks may be required to avoid low frequency and tonal noise problems. If the residences are at locations shielded from prevailing winds, a greater setback is needed than if they are in an exposed location.

Zoning. If residential or commercial development occurs in the vicinity of an established wind project or a designated wind resource area, conflicts are likely to occur. To prevent or minimize these, land use and permitting agencies should identify wind resource areas and establish appropriate zoning to prevent encroachment and future conflicts. (See *LAND USE*.)

Turbine modifications. Turbines can be designed or retrofitted to minimize mechanical noise. This can include special finishing of gear teeth, using low speed cooling fans and mounting them in the nacelle instead of at ground level, adding baffles and acoustic insulation to the nacelle, using

Establishing a Noise Complaint Resolution Process

Some permitting agencies have set up noise complaint resolution processes. A number where the agency can be notified of any noise concern is made public. Agency staff are prepared to respond to any complaint within 24 to 48 hours, and to work with the developer and concerned citizens to resolve the issue.

Complaints should meet certain validity requirements to ensure legitimate use of such a process. Information such as the date and time(s), location, noise description, and background noise conditions at the receptor should be documented. Agencies should review their statutory authority to see whether they are in a position to impose or enforce noise standards on a project, or merely play a mediating role.

vibration isolators and soft mounts for major components and brakes, and designing the turbine to prevent noises from being transmitted into the overall structure. There are costs associated with such modifications. If low frequency impulsive noise is a concern in an area, the permitting agency may limit the development of down-wind turbines.

Complaint resolution. Noise concerns may occur during the life of a wind project, particularly if residential land uses are allowed to encroach on a wind resource area. It is in the best interest of all involved to raise and resolve these concerns expeditiously. In some instances the noise may be caused by a unique environmental circumstance; in others there may be a mechanical or other problem with the turbine that requires attention. The process allows all concerned to be involved in a prompt evaluation of the complaint and a resolution consistent with the permit requirements.

BIRDS AND OTHER BIOLOGICAL RESOURCES

Biological resources include a broad variety of plants and animals that live, use or pass through an area. They also encompass the habitat that supports the living resources, including both physical features such as soil and water, and the biological components that sustain living communities. These range from bacteria and fungi through the predators at the top of the food chain.

Any construction project can affect the biological resources at the site by disrupting the physical and ecological relationships of the communities living there. Power plants can have direct effects by destroying habitat and some of the organisms found in it, and indirect effects by releasing pollutants that affect organisms' health or by producing noise or motion that affects the behavior of animals. These effects may be confined to a small part of the power plant where disturbance is most acute, or may be dispersed over a wide area.

Biological Resource Considerations

Because wind projects typically are located in rural areas that are either undeveloped or used for farming or grazing, they have the potential to directly and indirectly affect biological resources. Conflicts, if any, will depend on the plants and animals present and the location and design of the wind facilities. In some cases permitting agencies have discouraged or prevented development due to likely adverse consequences to these resources. In cases where sensitive resources were not present or where impacts could be avoided or mitigated, development has been allowed to proceed.

Biological resource concerns associated with wind development may include:

- Bird collisions with turbines, electrocutions, and other direct wildlife impacts;
- Loss of wildlife habitat and other indirect impacts on wildlife; and
- Loss of natural vegetation.

The problem of collisions between birds and wind energy facilities has been the most controversial biological consideration affecting facility siting. Wind developments with several hundreds to thousands of turbines, combined with site characteristics that attract some types of birds, have produced enough bird collisions and deaths to raise concerns by fish and wildlife agencies and conservation groups. On the other hand, several large wind facilities have been operating for years with only minor

impacts on birds and other flying vertebrates. Structures such as smokestacks and radio and television towers have been associated with far larger numbers of bird kills than have wind facilities. Other sources of bird mortality, such as highways and pollution, are responsible for a much higher proportion of total bird deaths.

Avian collisions and electrocutions. Like any tall facilities, wind turbines can be hit by birds; the movement of the blades is unique, and adds the potential for striking birds as they fly. Some bats have also been killed by wind energy facilities. These concerns apply both to the individual animals killed, and the potential for affecting the populations of particularly sensitive species. Studies reporting the losses of raptors (birds of prey such as hawks and eagles) at the Altamont Pass wind resource area in California and soaring birds (storks and vultures) at Tarifa in Spain, have made bird collisions with wind turbines the most publicized biological resource concern associated with wind development. These studies showed that bird collisions can be a serious problem and that it is important to carefully evaluate the potential for collisions before developing any wind resource. Since then, studies in other wind resource areas have shown that bird collisions are not a critical problem at all potential wind development areas. (For a review of information about avian collisions with man-made structures, see the California Energy Commission's *Effects of Wind Energy Development: An Annotated Bibliography*, listed in Appendix A.)

While collisions with wind turbines are relatively infrequent, they do occur and birds and bats are killed or seriously injured. Depending on the protective status or the number of individuals involved, these collisions may or may not be considered a biologically or legally significant impact. Because most raptors are protected by state and federal laws, any threat posed to these animals may present a legal barrier as well as a source of concern to local conservation groups.

Both the wind industry and government agencies are sponsoring or conducting research into collisions, relevant bird behavior, and mitigation and avoidance measures at wind facilities. Studies focus on the effects on birds of the wind facility components—for example, comparing mortality at open framed lattice towers and closed tubular towers. Other research is investigating birds' sensory physiology, and how it affects their ability to detect the components of a wind turbine. An example of this kind of study is painting different color patterns on turbine blades and observing whether the birds react to the turbines at a greater distance, or more rapidly (see Howell, Noone and Wardner, 1991).

Some of these studies are finding that both resident and migratory birds are involved in collisions. Birds typically migrate at altitudes of 1,500 to 2,500 feet (even migrating songbirds fly at an altitude of 500 to 1,000 feet), well above the top of turbine blades in most locations. Therefore, collisions during actual migratory flights should be rare. Studies of bird behavior around wind turbines have shown that when the turbines are visible, birds will change direction to avoid flying directly into turbines. In addition, water birds such as geese and swans tend to avoid the vicinity of turbines, keeping from 250 to 500 meters (800 to 1600 feet) away from them. (See studies by J. E. Winkelman, 1992.) As with other high structures, reduced visibility due to fog, clouds, rain and darkness may be a factor in collisions.

In some wind areas, large birds have been electrocuted on distribution or transmission lines. This can occur when the bird touches two electrical conductors or one conductor and a grounded wire, either on a power line, at a riser pole, or in a substation.

An extensive research project at wind facilities in southern California aims at developing a comprehensive way to measure the risk to birds not only of wind facilities, but of other human-created hazards such as highways or buildings. The study is under review by the National Wind Coordinating Committee's Avian Subcommittee. The California Energy Commission (CEC) and National Renewable Energy Laboratory are providing funding. This CEC study will continue through 1998.[1] The system for assessing bird risk, which was developed by CEC biologists and other experts, consists of several elements:

- **Bird Utilization Counts**, in which an observer notes the location, behavior and number of birds using the area. Bird behaviors noted include: flying, perching, soaring, hunting, foraging, and actions close (50 meters or less) to wind plant structures.

[1]An initial report is available from the California Energy Commission (CEC, 1995).

- **Bird Utilization Rate**, which is defined as the number of birds observed divided by the time of observation.

- **Bird Mortality**, a simple count of dead birds found within a given area of land.

- **Bird Risk**, defined as Bird Mortality divided by the Bird Utilization Rate. Bird Risk can be used to compare risk differences for many variables: varying distances from wind facilities; species, types, and all birds observed; natural communities; seasons; and turbine structure types. Bird Risk can be used to compare risk for other Wind Resource Areas and for other types of facilities such as highways, power lines, and television and radio transmitter towers.

- **Rotor Swept Hour and Rotor Swept Hour Risk**, two measurements that look at the effects of various turbine types.

Wildlife and habitat loss. Construction and operation of wind facilities can affect wildlife through:

1) Direct loss of habitat;

2) Indirect habitat loss as a result of increased human presence, noise or motion of operating turbines;

3) Habitat alteration as a result of soil erosion, introduction of non-native vegetation or construction of obstacles to migration;

4) Collision with structures, turbine blades and wires causing death or injury; and

5) Electrocution by contact with live electrical wires.

In most cases, the primary biological consequence of developing wind projects is the direct loss of wildlife habitat. While some small animals may be killed by construction activities, the more mobile species will leave the area. However, the resulting loss of habitat often reduces the available living space, food resources and, in some cases, the population levels of both prey and predator species. (Because wind facilities affect a relatively small proportion of the land they occupy, these effects should be minor in most cases.) Water quality and fish habitat can be affected if wind project development increases runoff or soil erosion from the site. See *SOIL EROSION AND WATER QUALITY* for discussion of this consideration.

Increased traffic, noise, night lighting and other human activities can discourage wildlife from using areas around energy facilities and cause indirect habitat losses. Most of these effects are temporary, occurring only during construction, but some continue during operations at reduced levels. These activities are not likely to result in biologically significant effects for most wind projects. However, many agencies may require them to be evaluated, particularly if legally protected animals are present.

Wind project construction also may alter an area or its habitats in a way that affects wildlife. For example, non-native plants may invade areas with ground loosened by construction and displace vegetation with higher wildlife food value. A disturbed ground surface can be more suitable for burrowing animals, many of which are attractive prey for raptors and other predators. Overhead lines, guy wires, turbines, and towers may provide new perching opportunities for raptors, but also increase the risk of collisions and electrocutions.

Wind facilities also may disrupt wildlife movements, particularly during migrations. For example, herd animals such as elk, deer and pronghorn can be affected if rows of turbines are placed along migration paths between winter and summer ranges or in calving areas. Because there is not enough information to predict whether this effect is likely to occur, it should be considered only where wildlife experts believe it is appropriate.

Natural vegetation loss. The significance of vegetation loss associated with a wind project usually depends on the size of the area disturbed and whether rare or sensitive native plants are affected. Construction of a wind energy facility including all of the components described in Chapter 2 disturbs some of the existing surface vegetation. Depending on the project design, these disturbances typically affect only three to five percent of the total surface area of a wind development site.

Site topography and the layout of access roads will affect the extent of vegetation disturbance and loss. Construction in steep areas can produce greater disturbance because these facilities require more

extensive "cut and fill" as well as longer, more complex road systems. These losses may be compounded by the establishment of invasive, weedy (noxious) plant species that thrive in disturbed areas and often must be controlled to allow native vegetation to be re-established.

For some wind projects, there are agreements or requirements to remove or prevent the regrowth of nearby trees that disrupt wind flow and reduce available energy (Gipe, 1995). The extent of the clearing typically depends on the wind speed, duration and direction; topography; and the relative height and placement of the turbines. In forested areas, permanent clearing of wide swaths along turbine corridors may be required. When applicable, biological resource evaluations of wind projects should consider the need for and effects of tree trimming and removal.

Biological Resource Strategies

Consultation. Appropriate planning and close coordination with permitting agencies can reduce the chances of expensive project delays. To avoid or minimize biological resource concerns, most permitting agencies recommend that wind developers consult with them and the appropriate natural resource protection agencies early in the site selection process. This allows the wind developers and agencies to determine the potential for biological resource conflicts and discuss any studies or information needed in the permitting process. Biological resource studies typically involve a review of the applicable scientific literature and natural resource databases; consultation with local, state, and federal experts; and field surveys to evaluate the resources present at a specific site.

An important concern is whether state or federally protected plants and animals (generally classified as "threatened," "endangered," or "species of concern" by natural resource or wildlife agencies) are known to inhabit, use or migrate through the area. Unique or rare habitat types (such as fens, vernal ponds, and savannas) also tend to be of interest. If any of these species or habitat types are likely to be present, more in-depth field surveys may be warranted. Some permitting agencies may also require an alternative site analysis as part of an application or environmental analysis document. In this case, the initial site evaluation may need to compare the biological resources of alternative sites and use the results in selecting sites for development.

Biological surveys. The timing of biological surveys and studies is important. Some resource information must be obtained seasonally. For example, some protected plants only bloom for a few weeks or months of the year and surveys may be required during that time to determine whether the proposed wind project is likely to affect the species in question. Bird use or migration patterns through an area may have to be surveyed over a period of several months or years. It is important that surveys be done at an appropriate time and with sufficient frequency to account for movements, seasonal variations and other biological considerations. The size and location of the study area is another important consideration when collecting biological resource information. Many agencies stress the need to consider the specific species involved. Some birds, for example, have large home ranges, and may be affected by a proposed wind project located away from their regular nesting or roosting sites.

Risk reduction. Theoretically, it should be possible to reduce the risk of bird collisions by avoiding sites near major bird feeding, roosting and resting areas, wetlands, rookeries, and low-level flight paths. Although research is in progress to identify other risk reduction measures, at this time there are no designs or modifications that have been statistically proven to significantly reduce the risk of bird and bat collisions with turbines. At present it may therefore be prudent to avoid areas with high levels of

Surveys Can Indicate Whether Bird Mortality Likely to be a Problem

The large prey base of ground squirrels at California's Altamont Pass might have suggested that raptors would be attracted to the area in large numbers. The potential for collision mortality with intensive wind energy development might have been foreseeable. By contrast, a biological reconnaissance of the Buffalo Ridge Wind Resource Area in Southwestern Minnesota indicated that serious conflicts between birds and wind projects were unlikely. Subsequent monitoring has confirmed that prediction.

Biological Resource Tips

For Permitting Agencies

1) *Become familiar with the literature on wind power development's impacts on biological resources, especially flying vertebrates. The California Energy Commission (CEC)'s Bibliography is a good place to start.*

2) *Consider requiring developers to follow standardized study plans to ensure that information gathered at all sites is compatible, and that experience at one site can contribute to learning about other locations.*

3) *Keep the level of studies appropriate to the level of risk likely to exist at the site, given the level of development considered for the area. A small, distributed generation project of only a few turbines is unlikely to pose as much risk as a large, widespread project.*

4) *Work with potential developers to find low risk sites that will keep the level of study and associated costs reasonable.*

5) *Use existing Avian Powerline Impact Committee (APLIC) guidelines to develop electrocution prevention requirements.*

For Project Developers

1) *Consider the biological setting early in project evaluation and planning. Hire a reputable biological consultant to conduct a preliminary biological reconnaissance of the site area. If a potential site has a large potential for biological conflicts, it may not be worth the time and cost of detailed wind resource evaluation work.*

2) *Contact the local resource management agency early in the process to find out if there are any resources of special concern in the area you are considering.*

3) *Involve local environmental/natural resources groups as soon as practicable. They will be less likely to react negatively to a project if they understand your requirements, and see that you are willing to seriously consider their concerns.*

bird or bat activities, especially if sensitive species are involved.

Appropriate equipment selections may help to reduce mortality, however. One study in the Altamont Pass wind resource area of California determined that tubular towers are associated with less collision mortality than open lattice towers, especially those with horizontal elements. Designs that reduce perching opportunities on all facilities also appear to reduce collisions. Applying the measures recommended by the Avian Powerline Impact Committee (APLIC, 1993) can reduce electrocution mortality.

The National Wind Coordinating Committee has established a Subcommittee on avian issues to assist developers and agencies in determining the potential for conflict between birds and wind projects. This NWCC Subcommittee is working to identify research priorities and to establish standard methods and measures for avian studies.

Unless protected plants, animals or their habitat are destroyed or displaced during construction, most permitting agencies are likely to find the non-collision consequences of wind development on wildlife to be insignificant. Construction of wind energy facilities can be carried out in a manner that

disturbs only a small amount of surface area, confining habitat losses to only a small part of the entire project area. In many cases, impacts on protected plant species can be avoided or minimized by using detailed information on the location of sensitive plants to plan the project facilities.

Direct wildlife habitat loss can be reduced through revegetation efforts, selecting turbine and transmission tower locations to minimize cut and fill, and carefully planning and constructing the access road network to minimize the number and width of roads actually built. Ensuring that only authorized access roads are used during operations and decommissioning is also important, as is, where practical, using locked gates to limit unauthorized use. Adding "perch guards" to power poles and turbine towers will discourage birds from landing on them and help prevent electrocutions.

Cover vegetation should be quickly restored at any disturbed area. Revegetation of parts of some wind development areas can be difficult because of extreme climatic conditions and high winds that may blow away seed, mulch and exposed topsoil. Revegetation methods, timing, plant species and seed mixtures all must be selected carefully to maximize the likelihood of success. Plantings can include sensitive species or seed mixes appropriate for site conditions. Many agencies will monitor a revegetation program to ensure that it is appropriately implemented and to learn what is and is not successful in their area to improve future revegetation efforts.

Designing and implementing water quality or soil erosion control measures that match the topographic and climatic conditions of the site can usually eliminate or minimize adverse effects to wetlands, water bodies, and fish and other aquatic species.

VISUAL RESOURCES

Visual or aesthetic resources refer to those natural and cultural features of an environmental setting that are of visual interest to people. An assessment of whether a project will be visually compatible with the character of the project setting or the natural landscape is based upon a comparison of the setting and surrounding features with simulated views of proposed project structures and facilities, as measured from several key observation points. Questions to ask include:

- Will the project substantially alter the existing project setting (sometimes referred to as the "viewshed"), including any changes in the natural terrain or landscape?
- Will the project deviate substantially from the form, line, color, and texture of existing elements of the viewshed that contribute to its visual quality?
- Will the project substantially degrade the visual quality of the viewshed, affect the use or visual experience of the area, or intrude upon or block views of valuable visual resources?
- Will the project be in conflict with directly-identified public preferences regarding visual and environmental resources?
- Will the project comply with local goals, policies, designations or guidelines related to visual quality? (Walker, 1996)

Figure 10. Compare the visual effect of widely-spaced turbines at a wind facility in Lake Benton, Minnesota (top) with the visual impact of a more densely-spaced array in California's Tehachapi Pass (bottom). Photos courtesy of the American Wind Energy Association (top) and the California Energy Commission (bottom).

Visual Resource Considerations

Wind projects have somewhat different impacts on visual resources than most other electric generation technologies. This is in part because they usually have been located in rural or even remote areas, often with few nearby residential developments and only intermittent human visitation and use. The potential for visual resource impacts is sometimes considered as part of the evaluation of land use compatibility among multiple parcels with either similar or a diverse set of uses. (In an area with many wind projects, one more could either blend in or it could become the one that tips the balance away from compatibility.) The degree to which aesthetic impacts may become an issue during the project permitting process is a function of the value people place on the visual quality of the project setting and many other individual considerations. Elements which influence visual impacts include the spacing, design and uniformity of the turbines, markings or lighting, roads built on slopes, and service buildings.

Spacing and turbine design. Effective use of wind resources requires maintaining adequate spacing between individual turbines as well as between rows, banks, or tiers of turbines. There is considerable visible motion in the blades when the winds blow. The perception of motion is intensified when turbines are closely spaced, are of mixed designs, or rotate in different directions. The spacing of wind turbines is determined by the distance needed for the winds to replenish. Turbines with shorter blades can be placed much closer together than larger turbines. The closer spacing of the older, large-scale turbine projects also meant that more units were concentrated closer together where today one new turbine may produce the same power as six to ten old units. Fewer and wider-spaced turbines present a more pleasing appearance than tightly-packed arrays (see Figure 10). Uniformity in tower design, number of blades and rotational direction is critical to minimizing visual impact.

Markings and lighting. Painted markings and/or lighting may be required on very large turbines, on facilities in certain types of terrain or at certain elevations, or on installations near airports where the project may extend into the flight paths. Tall towers for anemometers or meteorological data gathering also may require similar markings and lighting. Federal regulations require markings on all objects over 200 feet and state regulations may impose lower thresholds. Special designs, colors, or markings might be used to reduce avian collisions with turbines. (See *BIOLOGICAL RESOURCES*.) Clearly there are tradeoffs to be made between the use of such markings to prevent accidents and the undesirable visual impacts which may result.

Roads on slopes. Where wind turbines are arrayed along ridgelines to capture wind flows over the ridges, the units are visible over greater distances. Against the sloping terrain of the ridges, surfaces newly exposed by construction of access roads and turbine pads may contrast sharply with existing soils and/or vegetative cover. From a distance, the visual impact of roads on slopes may be greater than that of the turbines. Constructing roads on slopes to gain access to the ridge tops also opens the potential for erosion that can produce additional long-term visual changes in the site area. (See Figure 11.)

Figure 11. Roads on slopes can have a distinct visual impact, even from a great distance. Photo courtesy of the California Energy Commission.

Buildings and storage. Service and maintenance buildings located within the project leasehold may visually intrude upon the surrounding landscape. Other visually undesirable aspects of the area may include: crates or stacks of materials stored for project repair; barrels, reels, and piles of waste materials; and non-functional turbines that are awaiting repair or removal, or have been disposed of on-site.

Visual Resource Strategies

A range of mitigation measures is available to reduce the visual impact of wind projects. One major opportunity available to agencies having jurisdiction within a wind resource area (WRA) is

the preparation of maps, plans, guidelines and design standards for wind generation development prior to initiation of wind project proposals in that WRA. If more than one agency has jurisdiction, agencies should coordinate their efforts to ensure consistent application of the overall plans, standards, and guidelines within the WRA. The pre-development planning process for the WRAs should be open and accessible to all stakeholders in the project area. Early involvement helps identify sensitive resources and allows permitting agencies to consider tradeoffs and negotiate agreements independent of public sentiment over a specific project.

Once the overall development concept has been set for the WRA, site design criteria and requirements can be adjusted to fit site characteristics or mitigation requirements for each individual project. However, it is essential that individual project development and design be consistent with any overall plans for the WRA. All stakeholders and participants should be bound by the same set of guidelines and criteria.

Design strategies for reducing impacts to visual resources may include:

- Using the local land form to minimize visibility of access and service roads and protect soils from erosion and slippage.

- Consolidation of roads or use (and subsequent removal) of mesh mats or grating over existing vegetation for temporary access without roads.

- Soils and vegetation removed or reshaped during project construction on slopes should not be bladed or "side-cast" down the slope where the newly exposed materials may create a strong contrast in color and texture with the existing soils and vegetation.

- Use of low-profile and unobtrusive building designs to minimize the urbanized appearance or industrial character of projects located in rural or remote areas.

- Use of uniform color, structure types, and surface finishes to minimize project visibility in sensitive areas with high open space or other scenic values. *(Note, however, that the use of non-obtrusive designs and colors may conflict with efforts to reduce avian collisions, and may be in direct conflict with FAA requirements for distinctive markings.)*

- Selecting the route and type of support structure for above-ground electrical facilities as well as the method, mode, and type of installation (below vs. above-ground) can reduce potential impacts. Where multiple generation units are to be sited close together, consolidation of electrical lines and roads into a single right of way, trench, or corridor will cause lesser impacts than providing separate access to each unit.

- Controlling the placement and limiting the size, color, and number of labels or markings placed on individual turbines or advertising signs on fences and facilities.

- Prohibiting lighting except where required for aircraft safety prevents light pollution in otherwise dark settings (and may incidentally minimize collision by nocturnal feeders which prey on insects attracted to lights).

- Controlling the relative location of different turbine types, densities, and layout geometry to minimize visual impacts and conflicts within WRAs and specific project sites. Turbine types and those with opposing rotational directions

Scenic Impacts in the Eye of the Beholder

In one wind resource area, public and agency concern that the visible presence of the wind turbines would turn away visitors seeking the beauty of the open scenic vistas led to the establishment of a two-thirds-of-a-mile scenic setback corridor along all major access routes through the wind resource area. No wind development was allowed within this scenic corridor. Some fifteen years after development of the wind resources began, agencies are getting requests for tours of the wind developments from visitors who want to see the local wind industry.

can be segregated by buffer zones. Mixing of types should be avoided or minimized.

- Using air lift for transport of turbine components and turbine installation, major maintenance and removal to greatly reduce the size and placement of roads in remote locations or sensitive visual areas. (This also would lower impacts on public and rural roads and provide for quicker installation, but it is expensive and may be infeasible for larger turbines.)

As with land use strategies, costs associated with these strategies need to be taken into consideration.

A valuable process tool for the assessment of potential project impacts to sensitive visual resources is the preparation and use of visual simulations. Evaluation of these simulations allows the project developer, permitting agencies, and the public to see the site as it is, and to see the changes the project will bring to the existing setting and any sensitive resources. After viewing the simulations of important vantage points, all stakeholders can be

Visual Resource Tips

For Permitting Agencies

1) *Consider formulation of macro-level plans for the wind resource area, inviting public input and taking into consideration the cumulative impacts of multiple projects; coordinate planning efforts with all jurisdictions and stakeholders.*

2) *Set standards early and clearly; apply consistently to all development projects.*

3) *Educate all stakeholders about what to expect from a wind project; prepare to make impact tradeoffs.*

4) *Be aware that project development in sloping terrain presents extra design problems for minimizing impacts to visual resources.*

For Project Developers

1) *Prepare and use visual simulations of the post-project setting to identify potential impacts to sensitive visual resources.*

2) *Prepare a public education program on the benefits and tradeoffs involved in wind generation.*

3) *Listen to the community(ies) and stakeholders in all project phases; be prepared to adapt design to:*

    - *minimize industrial characteristics and structures; and*
    - *minimize visual exposure from sensitive areas.*

4) *If project is proposed in sloping terrain, design the project and the site layout to minimize visibility of roads and structures and to minimize visible aspects of cut and fill or side-casting of newly exposed soils during site and pad preparation and road construction.*

5) *Consider the overall benefits of using roadless project designs in remote or sensitive visual areas.*

involved in adjusting project layout and design to minimize potential impacts.

SOIL EROSION AND WATER QUALITY

Soil erosion is a normal process in which soil particles are detached and removed by wind or water. Deposition of this eroded material, especially into waterways, is called sedimentation. Land disturbance resulting from construction and operation of energy generation facilities can remove vegetation and loosen soil particles, allowing them to be swept away by wind or water. This can accelerate the erosion process thousands of times over normal rates, resulting in significant impacts (including both direct and indirect economic costs) both on and off the site.

Wind-induced erosion can increase fine particulate matter in air which can adversely impact human health and reduce visibility. Water-induced erosion, in addition to removing soil and decreasing its productivity, results in sedimentation which degrades water quality,[2] damages biological resources, exacerbates flooding, and accelerates filling of reservoirs.

Developing an area for energy generation facilities changes site and surrounding area runoff and drainage characteristics and may adversely impact resources on and off-site. Uncontrolled runoff from construction sites can cause short-term increases in turbidity and siltation in nearby watercourses. Deposition of this sediment in nearby water courses may adversely affect sensitive habitats, contribute to flooding, induce streambank erosion and alter downstream flow patterns. The costs associated with removing sediment from waterways, culverts and drains can be significant. Spills resulting from project construction and operation activities, such as refueling heavy equipment, may also impact water quality.

Finally, siting of energy generation facilities such as wind generation projects in flood prone areas may pose a risk to the project as well as adversely effect other downstream properties. Facility construction within a floodplain poses the risk of flooding at the site or may exacerbate flooding elsewhere.[3]

Soil Erosion and Water Quality Considerations

Although more dispersed than most other types of energy generation development, wind projects can still require a significant amount of land disturbance, especially where built on steep slopes. It is important to distinguish between temporary and permanent impacts.

Construction. Construction of a wind generation project consists of several activities: clearing vegetation; grading access roads; site and pad preparation; excavation for footings or foundations and trenching for underground services; and construction and installation of major equipment and structures. The initial grading activities remove the vegetative cover and strip or compact the top soil. In hilly terrain, cuts and fills alter the slopes and natural drainage patterns. Grading, excavation and trenching activities create large piles of unconsolidated soil. This is especially true for road grading in hilly areas where the excavated material is pushed aside and spilled down the slope ("side cast"). Heavy construction equipment compacts the soil. These activities expose the soil to the highly erosive effects of rain, overland water flow or wind. Exposed spoil piles are especially vulnerable to erosion. Alteration of natural drainages re-routes runoff into other areas, leading to erosion there. Soil compaction greatly increases the amount of runoff generated, leading to greatly increased erosion and sedimentation down-gradient. The steeper the incline, the greater the erosion consequences from road construction.

Project operation. Erosion and sedimentation continues during operation of wind projects as maintenance activities continue to impact access roads and turbine pads. Actively used unpaved roads have been shown to produce significantly more sediment that abandoned ones. Areas rendered impermeable by asphalt and concrete will generate storm water runoff that can cause erosion and sedimentation down-slope if proper drainage control is not provided. Unprotected soil on cut and fill slopes, berm faces and other areas will continue to erode. (See Figure 12.)

Soil Erosion and Water Quality Strategies

An important first step in selecting erosion and sediment control measures is estimating the amount of

[2]Uncontrolled erosion and runoff is the major cause of degraded water quality in the United States, depositing not only sediment but also metals, nutrients and other contaminants in adjacent waterways.

[3]Because of federal subsidized flood insurance requirements, most development is prohibited in a floodway, defined as the area necessary to convey the water from a flood with a one percent chance of occuring, more commonly known as a one hundred year flood.

runoff and erosion that may occur on site. Information on the different approaches to calculating both runoff and erosion is readily available from the US Natural Resource Conservation Service (formerly the Soil Conservation Service), local conservation districts, and cities and counties.

Selection of the appropriate erosion and sediment control measures will be dictated by site conditions, project details, costs and regulatory requirements. Taking into account erosion control concerns in the design stage of the project, such as having access roads follow existing contours to the greatest extent possible, may minimize the cost of installing and maintaining erosion control measures throughout the life of the project. The following are approaches to controlling erosion and sedimentation:

- Utilize existing terrain as much as possible to minimize the amount of grading that is necessary, leaving a smaller area that is vulnerable to erosion and taking advantage of the existing drainage ways.

- Schedule and stage grading and construction activities to minimize soil exposure and stabilize denuded areas, including drainageways, as soon as possible. (Depending on the severity and duration of the temporary disturbance associated with construction activities, and the season during which it takes place, temporary erosion prevention and restoration measures may be warranted.)

Figure 12. Site access and service roads can produce erosion in steep terrain. Photo courtesy of the California Energy Commission.

Where to Learn More about Controlling Erosion and Runoff

Local conservation districts, the Natural Resource Conservation Service and the appropriate city or county can provide guidance on development of a storm water management plan, calculating runoff flows and selecting control practices to ensure water quality is protected.

Local planning and permitting departments should have information on floodplain locations and expected flood levels and frequency. Inundation maps prepared by the Federal Emergency Management Agency (FEMA), show foot-by-foot inundation contours for most river/creek systems in United States. These FEMA maps should be available for review and copying at local land use planning or management agencies and are specific to the agency's own jurisdictional boundaries.

- Retain existing vegetation wherever feasible. In arid areas, protecting desert pavement or a surface soil crust may effectively control erosion as well.

- Divert runoff away from disturbed areas and ensure all sediment remains on site. Sediment ponds, straw bales, silt fences and other measures can ensure that any runoff leaving the site is not contaminated with sediment.

- Minimize length and steepness of slopes and keep runoff velocities low.

- Ensure all sediment retention and runoff control facilities are properly sized to accommodate sediment and water flows.

- Inspect and maintain erosion and runoff control measures.

Soil Erosion and Water Quality Tips

For Permitting Agencies

1) *Most erosion and sediment control plans are written to address the minimum requirements set forth by local ordinances and/or standards. Therefore, agencies need to provide clearly written, detailed guidance for plan writers to follow. The aim of such guidance and any implementing ordinance or standard should be to require an appropriate level of erosion and sediment control.*

2) *Ensure long-term monitoring and compliance with the erosion control plan. Revegetation standards can be based on performance of re-growth and cover.*

3) *For wind energy projects sufficient to disturb five or more acres, the project developer must comply with the individual state's provisions for the general construction permit for managing storm water runoff as required by the Clean Water Act (Title 33, United States Code section 1251 et seq.). This general permit requires the project owner to develop and implement a Construction Storm Water Management Plan. Local agency review of this plan will ensure that water quality issues associated with storm water management will be addressed.*

For Project Developers

1) *The design phase of the wind development project may be the most critical in realizing effective erosion and sediment control throughout the life of the project. During the design phase, the developer can minimize the footprint of the project and evaluate alternative turbine pad and access road siting and layouts.*

2) *Whenever possible, avoid road construction on steep slopes.*

3) *In selecting the appropriate erosion control measures, the developer should be aware that, although some measures may require greater expense initially, significant savings will occur over the life of the project in reduced maintenance and replacement costs. Furthermore, a well developed erosion and sediment control plan may also reduce regulatory delays in approving and monitoring the project.*

Construction in a flood plain may require special measures to ensure that structures do not unduly restrict the flow of floodwater and that they remain safe and intact during and after high waters. These additional measures may add significantly to construction costs. Generally, construction within a 100-year floodplain is prohibited.

PUBLIC HEALTH AND SAFETY

The public health and safety concerns for electrical generating facilities typically are associated either with the release of emissions into the atmosphere or solid and liquid wastes into surface or ground waters or the soil. Any of these can cause adverse public health impacts, violate standards for public health protection, or represent risks for workers. Wind facilities differ substantially from most other electrical facilities since they do not use a combustion process to generate electricity and hence do not produce any air emissions. In addition, the only potentially toxic or hazardous materials associated with most wind facilities are relatively small amounts of lubricating oils, and hydraulic and insulating fluids. (Bear in mind that even small leakages of such materials can have ground water or habitat impacts if left unchecked over time. See *SOLID AND HAZARDOUS WASTES*, page 57.)

Public Health and Safety Considerations

The primary health and safety considerations associated with wind are related to the movement of the turbine blades and the presence of industrial equipment in areas that are potentially accessible to the public. Depending on where they are located, wind facilities may also represent an increased fire hazard. Like all other electrical generating facilities, wind electrical generators also produce electric and magnetic fields.

Blade throw. "Blade throw" refers to rare events when a turbine blade or pieces of the turbine separate from the rotor and "fly" off downwind. Turbine blades have been known to delaminate and splinter in mid-blade without breaking. Wind turbines that have guy wires or other supports can also be damaged if a wire is snapped or one of the supports breaks. Turbine nacelles and rotor nose cones also may be blown off in high winds. These events are rare and usually occur under unexpected or unprecedented wind conditions. The distance a blade or turbine pieces may be thrown depends upon turbine height and blade length, piece size and mass, topography and wind conditions, but rarely exceeds 1,500 feet. Most pieces will be found within 300-500 feet of the tower.

Tower failure. Complete failure of turbine towers or guy wires usually bring the entire unit to the ground if the rotor is turning at the time or the problem is not immediately detected. High ice loads on turbines and towers, poor tower or foundation design, salt corrosion, and high winds increase this risk, which is more likely to be associated with hobbyist (as opposed to professionally-installed) systems.

Falling ice. Another rare problem can occur when low temperatures and precipitation cause a build-up of ice on the turbine blades. As the blades warm, the ice melts and either falls to the ground or can be thrown by the spinning blades. Falling ice from nacelles or towers can be dangerous directly under the turbine.

Attractive nuisance. Although most wind generation projects are located in rural areas on lands that are privately owned, many are visible from actively used public roadways and are relatively accessible to the public. Because the technology and the equipment associated with a wind generation project is sometimes new and unusual, it can be an attraction to those who want to see and touch an operating turbine or one that is inactive or disabled and waiting for repair or decommissioning. Members of the public who attempt to climb towers, open access doors or electrical panels could be subject to injuries from moving equipment, thrown parts, or electrical equipment during operation and from collapsed or downed turbines, exposed electrical facilities or other hazardous situations during decommissioning.

Fire hazard. In the more arid parts of the country, site characteristics that are preferable for development of wind electrical generation projects—high average wind speeds, low vegetation and few trees, and variable topography—may also reflect a high fire hazard potential during the dry months of the year. These projects typically are located in rural settings where dry land grain farming occurs or the natural vegetation grows uncontrolled and is available as fuel for escaped sparks or flames. Fires can originate when equipment is poorly maintained or not monitored, resulting in turbine bearings burning out or crankcases running out of lubricant and causing hot parts drop onto the ground. Fires have also started as the result of sparks escaping during welding; metal blades striking rocks during grading or discing; exposed drop cables from the top of exposed towers becoming twisted, shortened, and frayed during rotation of the turbine unit; electrical shorts occurring within a turbine unit; or careless operators. Fires also can be caused by electrical arcing in the transmission and distribution facilities. The two leading causes of fire are careless use of tall machines around overhead lines and electrocuted birds.

Worker hazards. As with any industrial activity, there is the potential for injury or the loss of life to individuals working with wind electric generators. There are no statistics to indicate whether wind facility work is any more or less dangerous than work on other energy facilities. However, several people have been killed when working above ground, and one by falling ice inside a tower.

Electromagnetic fields (EMF). Electric and magnetic fields are created when electrical charges flow within any object which conducts electricity. For a transmission line, these fields are created by current in a conductor. When a voltage is applied to a conductor, a magnetic field is created in the space

around the conductor. Field intensity decreases rapidly with distance.

In recent years some members of the public have become concerned regarding the potential for health effects associated with magnetic fields. This concern has been due to a perception that exposure to magnetic fields is associated with various forms of cancer or other diseases. Because wind development typically occurs at remote areas, the transmission lines connecting wind generators with the existing electrical system are usually located away from residences, schools or other potentially sensitive populations. In addition, the available EMF research does not establish that exposure to magnetic fields poses an increased risk to the public of cancer or non-cancerous effects. The National Research Council has concluded that: "...the current body of evidence does not show that exposures to (magnetic) fields present a human-health hazard" (National Research Council, 1996).

Public Health and Safety Strategies

Blade throw and falling ice. The most common method for reducing blade throw potential is the application of sound and detailed engineering and quality control. Braking systems, pitch controls and other speed controls on wind turbines should prevent design limits from being exceeded. These controls automatically stop the turbine from turning at high wind speeds.

Because of safety concerns with blade throw and structural failure, many permitting agencies have separated operating wind turbines from residences, public travel routes and other land uses by a safety buffer zone or setback. Minimum setback distances that have been established by permitting agencies range from 500 to 1,200 feet between wind turbines and residences or other habitable structures, 1.25 to six times the height of the wind turbine structure from public roads and highways, and 1.25 to four times the height of the wind turbine structure from adjacent property lines (see Appendix B). Distances less than 500 feet may be appropriate for major structural failure but inadequate for thrown or wind-blown pieces of turbines.

To reduce injury to workers, discussions of blade throw and ice throw may be included in worker training and safety programs. Project operators should not allow work crews in the field during windy and icing conditions, or when a turbine is operating out of control.

Attractive nuisance. Many jurisdictions have required fencing and posting at wind project boundaries to prevent unauthorized access. However, other jurisdictions prefer that the lands remain unfenced, particularly if located away from well-traveled public roads, so the area appears to remain open and retains a relatively natural character. Many jurisdictions require the developer to post signs with a 24-hour toll-free emergency phone number at specified intervals around the perimeter of the project site if the area is fenced and throughout the wind development area if it is unfenced. Liability concerns dictate use of warning signs and labels on towers, electrical panels and at project entrances. (See Figure 13.)

To reduce public hazards and personal injury, various agencies have required project developers to:

- lock access to towers and electrical equipment;
- place warning signs on towers;
- store spare parts and other equipment in fenced storage yards and to quickly remove equipment when it is no longer operational;
- require the lowest portion of the turbine blade to be at distances ranging from no lower than 15 or 30 feet above the ground; and
- clearly mark all guy wires or other supports to avoid collisions.

Fire hazard. The single most effective fire hazard avoidance measure is to underground all electrical wiring between turbines and the project substation. In fire-prone areas, most agencies establish permit

Figure 13. It may be necessary to post warning signs near wind facilities to protect public safety. Photo courtesy of the California Energy Commission.

Public Health and Safety Tips

For Permitting Agencies

1) *Establish and apply consistent safety setback distances from wind turbines and habitable dwellings, public highways and property lines. The setback should provide adequate protection from falling ice, blown turbine parts and major structural failure. Require prompt reporting of all events related to turbine damage. Require all turbines to be equipped with proven controls to stop turbine blades in extreme or emergency conditions, and with loss of electric power from the utility.*

2) *Require fencing if projects are located near public areas, posting along fence lines and within wind project areas and provision of 24 hour, toll-free emergency phone numbers. Also require clean-up of discarded equipment or materials and decommissioning of non-operating turbines and equipment.*

3) *Require pre-permit plans and provide for their compliance monitoring and enforcement in permits.*

4) *Consider the benefits of undergrounding all wiring between turbines and project substation.*

5) *Require locks and warning signs on access doors to towers and electrical equipment.*

6) *Require towers not be climbable up to 15 feet from the ground.*

For Project Developers

1) *Design facilities and turbine pads to prevent or avoid public and worker safety problems.*

2) *Establish worker safety training programs and emergency procedures.*

conditions on the project which address the potential for fire hazard. A fire control plan may be required. Typically they require a cleared space at the base of each turbine unit and at the base of each electric tower/pole or electrical facility to reduce fuel available to sparks or flaming debris from unexpected electrical and mechanical problems. However, falling electrocuted birds can be hazardous all along the wires' span, and maintaining such clearance can significantly impact land uses. Most agencies also require fire prevention plans and training programs to further reduce the potential for fires to escape the project and spread into surrounding areas. In some cases these training programs are performed in conjunction with local fire agencies. Local fire crews can be provided site access keys.

Worker hazards. General requirements or "safe work practices" for the protection of workers are common to the construction and operation of most projects. These practices include: lock-out/tag-out procedures and warning signs to reduce employee exposure to moving equipment and electrical shock; "hot work" safety procedures; and provisions for Neighborhood Emergency Response Team training. Education includes training personnel in potential hazards, safe procedures and practices, and preventive and protective actions. Implementation and enforcement of federal, state and local regulations should provide adequate margins of safety and adequate levels of fire prevention during construction and operation of a project.

Electromagnetic fields. Given the uncertainty over the potential for public health impacts associated with exposure to magnetic fields in the late 1980s

and early 1990s, a few states (Montana, Minnesota, New Jersey, New York, North Dakota, Oregon and Florida) have sought to limit field exposure levels to the levels from existing transmission lines by specifying limits on field strengths, either within or at the edge of the rights-of-way, for new lines. In Florida, limits on the strengths of magnetic fields from new transmission lines also have been specified. California has adopted EMF design guidelines that limit the magnetic fields from electric transmission lines through technology-related, no-cost or low-cost approaches with the intention that expenditures to minimize EMF exposure would be commensurate with the scientific research and knowledge and would not unduly impact transmission line safety, efficiency, maintainability, and reliability.

Measures adopted to either reduce exposure to magnetic fields or prevent any significant increase in field levels include: increasing the distance (for overhead lines) from the conductor to the ground; using field strength-minimizing conductor configurations; and undergrounding. The generally rural location of wind development projects also should reduce public concern over potential exposure to EMF from transmission lines since fewer people reside in or use these areas and there are more opportunities to locate lines away from people.

As with the mitigation strategies considered elsewhere in this section, there are costs associated with many of the measures which may be undertaken to ensure public health and safety. The cost of specific measures (such as undergrounding transmission wires) need to be taken into consideration, and tradeoffs among impacts thoughtfully weighed.

CULTURAL AND PALEONTOLOGICAL RESOURCES

Cultural resources are the structural and cultural evidence of the history of human development. They include both prehistoric and historic archaeological resources, as well as ethnographic and ethnic resources. Prehistoric archaeological resources are those materials relating to prehistoric human occupation and use of an area. Historic archaeological resources usually are associated with Euro-American exploration and settlement of an area and the beginning of a written historical record. Ethnographic resources are those materials important to the heritage of a particular ethnic or cultural group. Cultural resources may be encountered as sub-surface deposits or as surface trails, sites, artifacts, or structures. Cultural resources may also be associated with above-ground natural features, with plants or species harvested for traditional purposes, or with the surrounding physical setting.

Paleontological resources are the fossilized remains or trace evidence of prehistoric plants, animals, or very ancient humans preserved in soil or rock. Fossil resources may be found nearly anywhere but are most often found in geologic rock units comprised of water- or wind-borne sedimentary deposits. Fossilized evidence of ancient life-forms and environmental conditions may be weathering out onto the surface or may lie buried far beneath the modern-day ground surface.

Any type of project which includes vegetation clearance, disturbance of the ground surface, or excavation below the ground surface has the potential to affect archaeological and paleontological resources which may be present in the area. Additional impacts may be caused by compaction of the ground by heavy equipment or by the creation of improved public access to rural or previously isolated areas. The potential for impacts to cultural and fossil resources usually is directly correlated to the amount of ground disturbance, but even a “small” project area can contain particularly sensitive and valuable resources.

Cultural and Paleontological Considerations

With concentrations of turbines, multiple access roads, and myriad distribution and transmission lines, a large wind facility has the potential to impact most types of cultural and fossil resources. A dispersed turbine layout design with fewer turbines and consolidated service facilities reduces potential impacts. The extent of the potential for impacts will vary with the topography, vegetation, the extent of the resource area, and the presence or absence of other developments. Techniques for data recovery and mapping of the fossil record may make it unnecessary to redesign or modify the turbine layout design.

For certain types of cultural resources, the physical setting and vicinity of the resource site contribute materially to its value. In this case the area of potential impact may include areas within audible or visual distance of the sensitive resource. For example, wind generation sites are often located on the sides and ridges of hills and may be near the coast or shoreline of large water bodies. Such areas also were used by native peoples for traditional

Cultural and Paleontological Tips

For Permitting Agencies

1) *Identify potentially sensitive resources and involve all stakeholders early on.*

2) *Consult with qualified professional specialists who are familiar with cultural and fossil resources in the project development area.*

3) *Sensitive resource sites may be confidential to Native Americans. Agencies should respect this confidentiality and may need to work closely with tribal representatives to protect these resources.*

4) *Review project design to avoid impacts to sensitive resources.*

5) *Require appropriate mitigation of unavoidable impacts and monitor to ensure measures are implemented.*

For Project Developers

1) *Same as 1, 2, and 3, above.*

2) *Design project site layout to avoid sensitive resources if possible.*

3) *Prepare a monitoring and mitigation plan for protection of sensitive resources during construction and operation of the project.*

4) *Allow adequate time in the project schedule for data and specimen recovery, mapping, analysis, and reporting.*

resource harvest and seasonal and religious ceremonies. Wind development in such locations has a greater potential to affect large-scale, above-ground cultural resources or resource settings. The area of potential impact may extend only a few tens of feet or may extend out to one-quarter mile or more. This type of impact is most likely to be associated with long-standing resource collection areas, landmarks, or sacred areas and features. Cultural resource impacts in these areas may also include concerns about disturbance of traditional practices due to noise and visual impacts.

Cultural and Paleontological Strategies

In most states, cultural and fossil resources are protected by several federal laws, as well as state and local laws.[4] During project design and site development, cultural and fossil resources sites should be avoided and protected. Usually the location of most wind turbine towers and related access roads, transmission lines, and service or maintenance structures can be adjusted during the design phase to avoid impacts to known surface or sub-surface cultural and fossil resources.

If project development impacts cannot be avoided, a program of data and resource recovery can usually mitigate any potential effects to cultural and fossil resources (both of which generally employ similar data recovery techniques). An important first step in choosing appropriate mitigation measures is the evaluation, by a knowledgeable, qualified professional, of the project setting and site topography, to estimate the type and extent of the resources present (or expected) and the type and degree of mitigation/data recovery/monitoring required. Preparation of an archaeological resource monitoring and mitigation plan will provide a set of contingency

[4]Appendix A includes an annotated list of the relevant federal statutes and regulations.

measures for previously unknown resources that may be encountered during project construction. The plan should be developed early and taken into account during the design phase of the project.

SOCIOECONOMICS, PUBLIC SERVICES AND INFRASTRUCTURE

Many agencies evaluate the potential for socioeconomic, public service and infrastructure consequences to an area when planning for or permitting the development of any sizable piece of land or significant project. Development projects may create new employment opportunities and local economic activity and contribute to local tax revenues. They may also increase demand for available housing, public services and infrastructure (utility and fire protection services, transportation systems), or adversely affect adjacent property values. Other impacts that may need to be considered include tourism, airport operations, and electromagnetic interference. As with any siting decision, care must be taken to apply and enforce environmental laws fairly and consistently, and that facilities which may be perceived as less desirable are not located predominantly in minority or low-income communities.

Socioeconomic/Public Services/ Infrastructure Considerations

Employment. Development of a wind generation project may cause a small, long-term increase in local employment and could benefit the economy in the project area. Local businesses may receive increased revenues from the purchase of materials and supplies needed for operation and maintenance throughout the lifetime of the project. While wind generation projects tend to be located in rural or remote areas, the number of workers required for construction and/or operation is relatively few. Thus there is no need to import a large work force and project development is not likely to overburden the resources of most communities.

Public services. Development of wind generation projects are also not likely to cause significant impacts on the ability of a community to provide public services in the project area. The relatively small number of operation and maintenance employees places a low demand on public services such as water, gas, and sewer services. Some wind projects can meet on-site electrical services from their own generation.

Fire services. Fires associated with wind generation can be started by downed transmission and collection lines, electrocuted birds, metal or parts thrown from malfunctioning turbines, operating tall equipment in the vicinity of electric lines, or by human error. Depending on whether the project is located in a fire prone area and on the design and installation of the turbines and electric lines, wind development may increase the need for fire protection services (see *PUBLIC HEALTH AND SAFETY*). However, a wind project generally should not have a significant impact on an agency's ability to provide services to the entire community.

Transportation systems. There may be a potential for wind projects to affect rural roads designed for infrequent traffic or lightweight vehicles. Construction and operation of a wind generation facility requires use of heavy equipment for site preparation, transport of construction supplies and project components, and for the erection of turbines and electric poles and towers. Existing road beds may have to be rebuilt or reinforced to support such additional loads without degradation, and the frequency of scheduled maintenance on these roads may have to be increased.

Airports. Turbine height and location, as well as the concentration of turbines, may be of concern as an aviation navigation hazard. In one wind resource area, the whirling blur of turbine blades has caused ghost readings of non-existent aircraft on radar screens at the local airport. Location of turbines along the crest of ridges within the approach paths for airports may create safety concerns for aircraft operators.

Electromagnetic interference (EMI).
Electromagnetic interference is the disruption of electromagnetic signals used in communication technologies including radio, television and microwaves. It has been discussed as a possible problem with certain aspects of wind generation, primarily the rotating blades of wind turbines and very high voltage electric transmission lines. UHF television signals are most easily reflected by turbine blades and television reception within three miles (UHF) or 3/4 mile (VHF) of a turbine of sufficient size may be affected. The degree of interference depends on the blade material, turbine location relative to the signal path, and turbine size. Interference with FM radio reception has not been reported. Microwave repeating stations are often located on remote and rural hilltops. These stations

rely on unobstructed line-of-sight paths for their signals and consequently may be affected by wind projects which intrude into the beam corridor. Turbines can be built in close proximity to such stations provided no portion of any structure intrudes into the beam path. In addition, the electrical circuits in the turbine may transmit an electromagnetic signal (noise) if it is not properly installed and maintained. If this occurs, the Federal Communications Commission requires that the interfering signal be eliminated.

Local finances. Most jurisdictions in the United States assess and collect some type of property taxes. Development of wind resources may also provide a new income to landowners and an increase in the local tax base. The amount of property taxes likely to be paid by wind developers each year is based upon the land and facility value once the project is operational. When a private wind developer constructs a project on publicly-owned or managed land, property taxes may be collected on the value of the facilities and equipment, but usually not on the land itself. If the project developer is a government agency or a publicly-owned utility, they may be exempt from paying property taxes. If there are adverse consequences to public services or infrastructure that result from development of these projects, the community may not receive tax income to respond to the consequences. A community may also be harmed financially if the community suffers adverse consequences from a project but the tax revenue goes to another entity such as a county.

Property values. Wind development projects have the potential to affect property values but it remains uncertain whether such effects are real or perceived. Whether and how the value of property under the turbines is affected depends on the project's impact on uses of the land and how payments to the landowner are structured. In one wind resource area, property owners immediately adjacent to a wind development leasehold argued that wind turbine operation had significantly reduced their property values.

Tourism. Tourism is a unique consideration for a few communities. Some local governments have had concerns about potential negative impacts of wind development on local tourism. In one instance, the local government is now finding that many visitors are drawn to their area, asking about wind energy technology and seeking tours of the wind facilities. This has enhanced the area's attraction to tourists and provided a small boost to the local economy. For this community, the wind turbines and their setting have even been used as backdrops for television commercials.

Socioeconomic/Public Services/ Infrastructure Strategies

Performing an objective evaluation of the size of the project and the construction workforce, the timing of project construction and operation, and the potential overlap with other projects that may draw upon the same community resources is the key to resolving most concerns associated with socioeconomics, public services and infrastructure. Since the project may include construction of new roads and services into previously inaccessible areas, new electrical interconnections and transmission lines, the area affected by project development may include several communities and extend into the jurisdiction of more than one agency.

An assessment can be conducted when adopting or modifying a regional land use plan, when undertaking a general plan or zoning process, or when permitting an individual project. The earlier the assessment is performed, the greater its value will be in providing guidance to developers, information to the community and data to decision-makers. The assessment should look at the construction and operation of the development[5] and compare the existing community resources with the expected development-related changes in population and the need for services. Depending on the life-time of the development and its significance to the community, the assessment can also consider the project's decommissioning. In performing the assessment, it is important to define the area that may be affected. This may include an area located within one to two miles from an individual project site for concerns about community disruption or an area of one to one-and-a-half hours' driving time from the resource area in the case of a concern such as housing or worker implications.

For wind generation projects, especially those with dispersed turbines rather than concentrated masses, significant impacts on community resources are unlikely. For most project proposals, interagency coordination and a simple review of basic design features should provide adequate information and resolve the potential for project impacts.

[5] "Development" as used here can range from the entire wind resource area to an individual project.

Demographics, employment, and public services. It is not expected that unique strategies for socioeconomic, employment or public services will be necessary for most wind generating facilities.

Fire services. In fire sensitive environments, the developer and permitting agency should work closely with fire departments to develop construction requirements and performance standards for wind generation projects. The design and placement of access roads and electric facilities is particularly important in assisting with fire avoidance, suppression and control. Undergrounding of all electric wiring up to the project's substation will avoid most potential problems. In many cases, joint training of fire agency and protective services staff and industry personnel increase their overall ability to respond to emergency situations. Most agencies charge developers for the cost of fighting fires started by their equipment or workers. Permits for some wind projects in fire prone areas include mutual aid agreements that extend to include all agencies with jurisdiction over a particular wind project site. (See *PUBLIC HEALTH AND SAFETY*.)

Transportation systems. The permitting agency can minimize impacts on transportation systems through careful route selection for transporting heavy equipment to and from the project site and by incorporating road construction, maintenance and seasonal load restriction requirements into permit conditions. Road requirements should consider other concerns such as erosion, visual impacts, and biological resources. They should also consider the landowner's needs and future closure of the facility. If the roads are likely to increase public access to an area which may result in safety, vandalism or environmental concerns, the number of roads should be minimized and use of the roads controlled. In cases where more than one wind developer shares access roads, the permitting agency should coordinate requirements and efforts so all developers who benefit also contribute to the costs.

Developers can be made responsible for impacts on public roadways through route requirements, condition inspections and timely repair compensation. Where project roads enter paved public roads, paved aprons for a given distance may be required.

Airports. Conflicts between wind development and airports can easily be avoided through careful coordination between wind developers and local airport officials in selecting sites and turbine types.

Electromagnetic interference (EMI). Non-metal blades currently used in most wind turbines have greatly reduced concerns regarding electromagnetic interference. If interference problems are likely to exist after construction of a wind facility, highly directional satellite dishes, deep fringe antennas, local television repeaters, circularly-polarized transmissions, and cable or satellite reception are potential mitigation measures. Small, inexpensive digital satellite dishes are becoming more common, reducing the likelihood of impact and making this mitigation readily available.

The microwave communications industry has tools which define the necessary beam path's location and height above the ground between stations. Wind project developers can easily avoid creating interference by working with operators of microwave communications stations in the vicinity of the project.

Local finances. In most cases, wind equipment and related development will be assessed for property taxes at the prevailing industrial use rate. The rate should be correlated with the cost of providing services to the wind development (e.g., road maintenance, fire protection). Some states have reduced or exempted wind from property taxes to encourage development. In instances where a developer is

Property Tax Revenues vs. Cost of Additional Services

The long term value of tax revenues from wind facilities was significant enough ($1.3 million annually) for one city to extend its jurisdictional boundaries farther into the wind development areas and wrest most of the wind leases (and revenues) away from the adjoining jurisdiction.

On the other hand, some states have reduced or exempted wind from property taxes to encourage development. Developers, planners, and community stakeholders need to take a realistic look at the property tax implications of a proposed project. Both projected revenues and the cost of additional public services need to be considered and balanced.

Socioeconomic/Public Services/Infrastructure Tips

For Permitting Agencies

1) *Early in the planning phase for a wind project, identify any community services and infrastructure that may be affected by a project and work to involve all stakeholders in solving any conflicts and designing mitigation plans.*

2) *Carefully review project design to avoid impacts to sensitive resources.*

3) *Work with all the concerned stakeholders to develop appropriate mitigation for unavoidable impacts and monitor compliance to ensure the measures are implemented.*

4) *As any changes to the property tax rate are considered, local taxing jurisdictions should seek to recover only those costs directly associated with services to the wind development to avoid discouraging new wind projects.*

For Project Developers

1) *Coordinate with the local agencies and service districts to determine if and how the project may affect community services and infrastructure.*

2) *If possible, design the project and phase construction to avoid or minimize potential impacts on community services and infrastructure.*

3) *When possible, draw from the local labor pool and contract with local providers for supplies and equipment during the construction and operation phases of the project.*

exempt from taxation, the developer may agree to pay fees for use of the land in lieu of property taxes to compensate for any additional burden placed on local services.

Property values. At least one developer avoids locating wind facilities within a half mile of any existing residential developments to avoid issues over property value impacts. Some permitting agencies have established land use buffer zones between wind facilities and residential land uses to reduce or eliminate land use or property value concerns.

Tourism. Permitting agencies and project developers should work together on opportunities to enhance the potential for wind energy projects to benefit local tourism. Some communities have created information centers or viewpoints along major roads or highways within the wind resource area to educate the public and allow safe observation at locations where wind turbines are not directly accessible. One community hosts an annual "wind fair" in coordination with wind project developers while another provides information on wind development over the radio for travelers passing through the wind resource area.

SOLID AND HAZARDOUS WASTES

Most human activities produce some wastes which must be properly disposed of to protect the environment. These may be solid materials or liquids, inert or reactive, benign or hazardous. Wastes are produced during construction, operation and decommissioning of power plants, but their quantities and characteristics are a function of the type of facility. It is important to plan for all three phases to prevent waste disposal from becoming a problem. For a coal-fired power plant ash is the most critical solid waste; for other mechanical plants the many lubricants, solvents and other fluids that keep the plant operating smoothly may be the most important wastes from an environmental perspective. When a power plant ceases to operate, all of its

Figure 14. Wind turbine parts can become solid waste, and need to be handled appropriately. Photo courtesy of the California Energy Commission.

components may become wastes which must be appropriately handled. (See Figure 14.)

Solid and Hazardous Waste Considerations

A wind project may be spread out over a wide area, and consist of several individual sites. Waste materials will be generated during construction as well as operation of the facility. If turbines are not well-designed and maintained, fluid leaks at the turbine may occur, resulting in fluids not only dripping directly downward but flying off the tips of the blades and contaminating the ground below. These may be gearbox oils, hydraulic and insulating fluids. Some fluids may become hazardous wastes when spilled on the ground. On-site storage of new and used lubricants and cleaning fluids also represent hazards.

Solid and Hazardous Waste Strategies

It is necessary to ensure that construction wastes are collected from all such sites and disposed of at a licensed facility. When the facility is operating, waste production may be concentrated at service facilities and control centers, except when units are being serviced. Waste disposal practices should not be different from those required at other power plants or repair facilities.

Problems with fluid leaks can be anticipated and avoided by use of non-hazardous fluids. If any hazardous fluids (or fluids which may become hazardous wastes if spilled) are used, a Hazardous Materials Waste Plan should be drawn up to address avoidance, handling, disposal, and clean-up. Turbine maintenance facilities and major turbine repairs can be done off-site. Some permits have banned on-site repairs of construction and maintenance vehicles.

AIR QUALITY AND CLIMATE

The emissions from power generation plants typically raise concerns about air quality and micro-climate impacts. These concerns are addressed through the applicable facility siting and permitting processes.

The air quality impact analysis for most power generation technologies focuses on the expected, day-to-day, ongoing emissions of both “criteria” and “non-criteria” air pollutants from the construction and operation of the project.[6] Typically, an air quality impact analysis includes pinpointing the location of the project site; reviewing local topography, regional climatology and meteorology, and existing ambient air quality conditions in the project area; evaluating potential project emission types and rates; and the types of air pollution control measures proposed. The analysis also evaluates whether the project will conform with all applicable air quality laws, ordinances, regulations, and standards and whether the project is likely to cause new violations or contribute to existing violations of these standards for ambient air quality.

Air Quality and Climate Considerations

Air quality. Wind generation is a non-combustion process relying on the direct conversion of physical/mechanical energy into electrical energy. Thus unlike conventional electric power plants there are no emissions from the generation process. Indeed, to the extent that energy from wind facilities displaces electricity from fossil fuels, pollutant emissions in other areas can be reduced.

Federal, state, and local air quality plans are concerned with particulate matter less than 10 microns in diameter, known as PM_{10}. Production of particulate matter is the only air quality impact likely to occur in conjunction with a wind energy facility, and is primarily associated with construction activities. These pollutants will be largely confined to the project area. No negative long-term air quality impacts are likely to occur.

Climate. The effects of wind turbines on local micro-climates are not well known. However, the

[6]Under federal standards, “criteria” pollutants include sulfur dioxide, oxides of nitrogen, particulate matter of various categories (soot), carbon monoxide, ozone, and lead. Non-criteria pollutants include organic toxic substances like dioxins and metals such as mercury.

effects of semi-porous wind breaks (which are similar to the effects of a turbine rotor) have been studied. Downwind effects include decreased wind speed, increased turbulence, slightly increased relative humidity, and slightly increased soil moisture. The cross-sectional area of reduced wind velocity is slightly larger than the area swept by the blades, and extends about seven to twenty rotor diameters downwind. These effects are moderated by changes in wind direction and the height of the rotor above the ground. Turbine-induced changes are expected to be within the range of effects caused by natural processes. Any increased soil moisture in moist environments such as coastal areas should have no appreciable effect. Thus, wind project-induced microclimatic changes should be insignificant.

Air Quality and Climate Strategies

During the siting and permit processes, the question of whether construction and operation of the wind generation project will impact air quality is often addressed. While it is difficult to accurately estimate project construction emissions, the potential for construction impacts on ambient air quality generally can be adequately mitigated during sensitive operations so the overall impact is likely to be relatively small and temporary. The permit process will determine whether the project will comply with the applicable federal, state, and local air quality requirements.

CHAPTER 4 REFERENCES

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