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Rolette, ND 58366
7 August 2005

RECEIVED
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ND PUBLIC SERVICE COMMISSION
SUSAN E. WEFALD

Ms Susan Wefald
Commissioner
Public Service Commission
State of North Dakota
600 E Boulevard Ave
Dept 408
Bismarck ND 58505

Dear Ms Wefald:

J T and I deeply appreciate the fact that you docked as part of the wind project our letter and materials. Thanks also for placing us on your mailing list to receive orders and other documents you issue which relate to the case. You mentioned that we might wish to get an attorney and I believe we did so for on Thursday we contacted Jack MacDonald of Wheeler Wolf in Bismarck for help.

Enclosed are parts of a new book about wind turbines. I think you will find this extremely interesting. In addition to being tremendously upset about the destruction of our lives here, we have the hope of making you inquire about the viability of their geographical plans. For example couldn't they build the towers up and down State Route 3 along with the transmission line? That seems the way the turbines are placed in Europe and it largely seems to have worked out without wrecking people's lives and equanimity. That way the beauty and integrity of the land could be maintained and a distant independence from oil could at least begin.

Thank you for your concern for us and I will be calling the number you gve me tomorrow to request intervention.

Very truly yours,

Roberta McIntire

Roberta McIntire

45 PU-05-47 Filed: 11/9/2005 Pages: 45
Additional letter & material to Comm. Wefald
J T & Roberta McIntire

43 PU-05-305 Pages: 43
Additional letter & material to Comm. Wefald
by J T & Roberta McIntire
11/09/2005 C: Comm Legal Illona, Jerry, Annette . .

Public Service Commission

Commission reviews PPM Energy's request

Company planning largest wind farm project in the state

By Matt Mullally
Tribune Editor

Public Service Commissioners (from left to right) Kevin Cramer, Tony Clark and Susan Wefald) listen closely to a witness during a public hearing on PPM Energy's permit application for a wind farm and transmission line project north of Rugby. The hearing was held July 28 in the Pierce County district courtroom.

Staff photo

PPM Energy would like to begin construction on its proposed large wind farm and 230 kilovolt transmission line project north of Rugby by late fall.

However, before it can proceed it will need the approval of the State Public Service Commission (PSC).

The PSC held a five-hour public hearing in Rugby late last month, listening to testimony from PPM Energy representatives as well as hearing comments from the public.

PPM Energy filed two permits with the Commission — to construct up to 100 1.5 megawatt wind farm towers north of Rugby — and establish a 9.5 mile 230 kilovolt transmission line from its wind farm to the substation east of Rugby.

Witnesses for PPM Energy discussed construction plans, construction timeline, benefits to the community and region and identified any environmental impact on the area and other challenges in the construction of the project.

Raimund Grube of PPM Energy said other sites were initially looked at over a three-year period, but the Rugby location was the best fit for the company's plans. Wind testing produced favorable results; it was close to a nearby transmission line connection; offered low environmental impact; and had strong support from landowners in the identified project area. The wind farm would consist of up to 100 towers of either 1.5 or 3 megawatts in size, ranging in height between 300 and 400 feet.

A "first" for the PSC

PPM Energy's request for permits for a wind farm and transmission line marked the first time the PSC had held a hearing and would review applications for a large wind energy project.

As a result, commissioners Susan Wefald, Kevin Cramer and Tony Clark and their staff asked several questions of PPM Energy representatives following witness testimony.

One of the questions was regarding final placement of the wind turbines and whether the Commission would be given enough opportunity to review the final map. PPM Energy is still in the process of determining the location of its towers in the project area, which encompasses 46,000 acres. However, only between 50 and 70 acres will be used.

When that final map will be completed has not been determined, but the PSC requested six to eight weeks to review the map.

PPM Energy did foresee a possible problem in allowing that much time, as it could delay their plans for construction. A compromise was proposed by PPM Energy which would enable some initial construction work this fall, including building roads, in return for more time for the Commission to review the site map for the turbines. No actual construction on the turbines will be permitted until the map has been reviewed by the PSC. Commissioners planning to review the request.

Commissioners also commented on what seemed to be an ambitious time schedule for PPM Energy to complete the project.

Grube said there is an urgency, given the limited supplies for turbines and what is anticipated to be a high demand in the near future. As a result, moving forward soon with this project would insure cost certainty on the turbines and that orders can be placed.

Other questions involved what environmental impact the project would have on the area. PPM Energy has worked with the North Dakota Game and Fish Department and U.S. Fish and Wildlife on the potential location of its turbines and the transmission line. Under the project, only one transmission line structure would be placed in a wetland. Other issues raised included setback requirements of the wind turbines from occupied structures as well as noise issues near the turbines.

Early in July, the Pierce County Commission granted PPM Energy a conditional use permit for the project, which included a few variances from existing zoning and planning ordinances, including a 1,000-foot setback from occupied residences. The county also allowed for a height variance for the towers to exceed 300 feet. Noise levels also must be line with a 50 dBa from a required distance from an occupied residence.

Other setbacks PPM Energy will follow include at least a 400-foot setback from roads and transmission lines, a one-quarter-mile setback from National Waterfowl production areas and a 500-foot setback from large wetland areas.

Economic benefits

It is projected over $500,000 in annual county-school district property taxes will be paid out from the project. In addition, landowners with easements with PPM Energy to construct turbines or transmission lines on their property will receive lease payments. PPM Energy officials said all land easements have been made.

The facility could also mean up to 10 full-time positions.

At the peak of construction, nearly 200 workers will be employed to construct the wind farm and transmission line. The new line will be aligned about 150 feet from the existing 230 kV transmission line which runs north from the substation east of Rugby.

Public input

A handful of local residents commented on the project, which would be the largest wind farm facility in the state and is estimated to cost between $170 and $190 million to construct.

Roberta McIntire, a landowner north of Rugby, addressed concerns about the project which she and her husband, J.T., do not support.

The McIntires own a five-acre farmstead, and although their property is not included in the project, its location near other property which will have turbines and transmission lines will cause adverse effects on their property and livelihood, she contended.

The potential noise from the towers and transmission lines will make it difficult for them to work on their farm as professional writers and raise small animals.

She questioned how long landowners in the area were aware of this project and said she and her husband were not notified of it.

The McIntires support economic development for the area but don't believe this is a worthy project, and it will do more harm than good.

However, county commissioner Mike Christenson disagreed.

He told the commission almost all landowners in the area support the wind farm, as it will provide much-needed income for some and mean additional tax money for the county and school district as well as some new jobs.

Ben Axtman, who resides north of Rugby but does not have any property in the project area, also agrees the wind farm will be positive for the region. Axtman added there is only a certain level of usability for some of the land in the project area. Only so much is suited for farming. As a result, the project won't adversely affect the land. He said the region and state would be very well served by this project.

What's next?

The PSC will review the data submitted by PPM Energy and the permit application before making a decision whether to grant a site compatibility and corridor compatibility permit to PPM Energy.

The company still must establish a power purchase agreement as well as develop an interconnect agreement and file for a production tax credit.

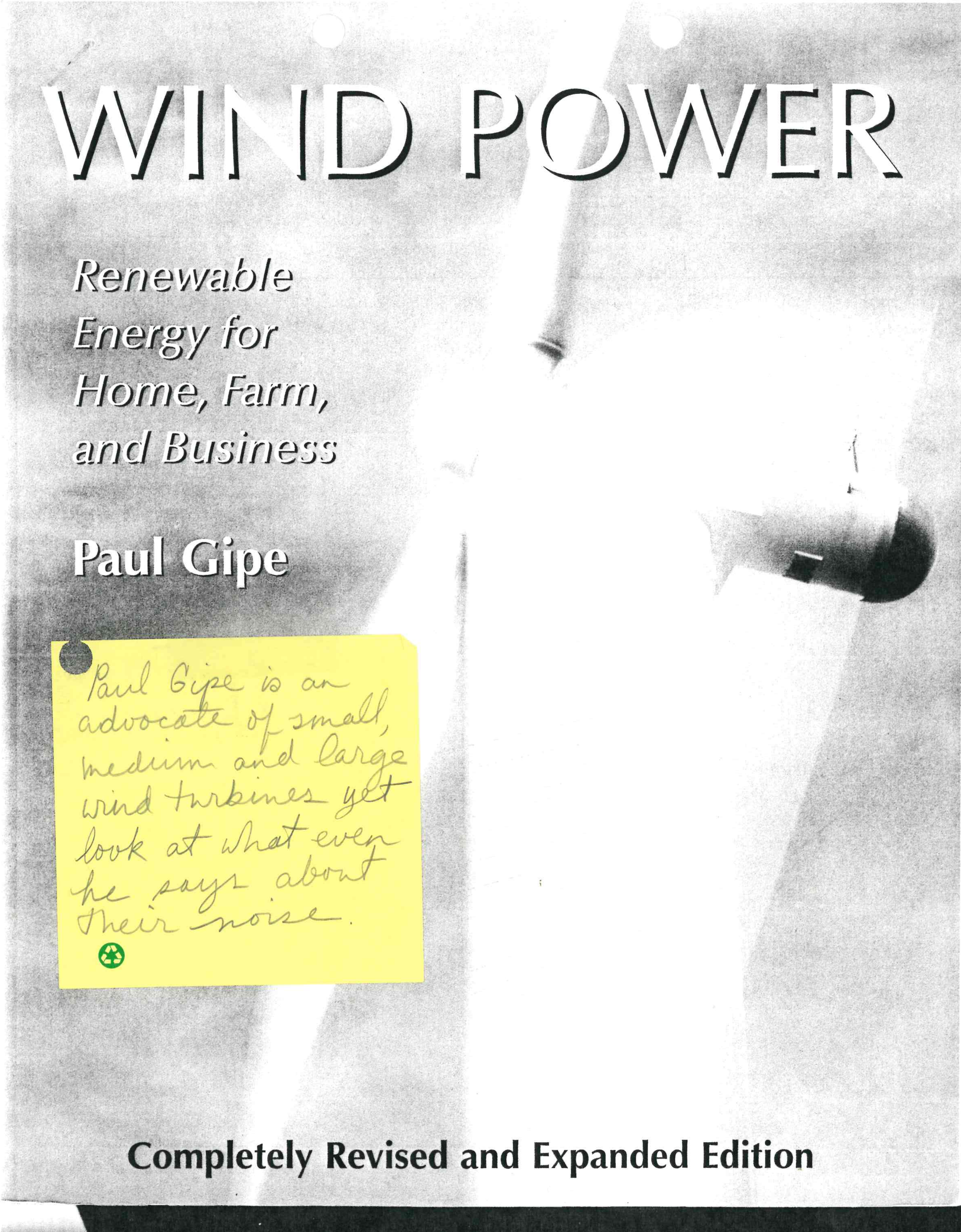
PPM Energy will likely finalize the turbine locations later this month and hopes some construction will start later this year before full-scale construction next spring.

Testing and operation would follow with the facility scheduled to be operational by fall of 2006.

WIND POWER

Renewable Energy for Home, Farm, and Business

Paul Gipe



Paul Gipe is an advocate of small, medium and large wind turbines yet look at what even he says about their noise.

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"Paul Gipe's *Wind Power* is a must for everybody who's involved in the wind energy sector— or wants to be involved in the future. The reader will get a comprehensive overview of one of the most important energy technologies to save the world's climate: wind energy."

Sven Teske, Renewable Energy Director, Greenpeace

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Doug Pratt, Technical Editor, Real Goods

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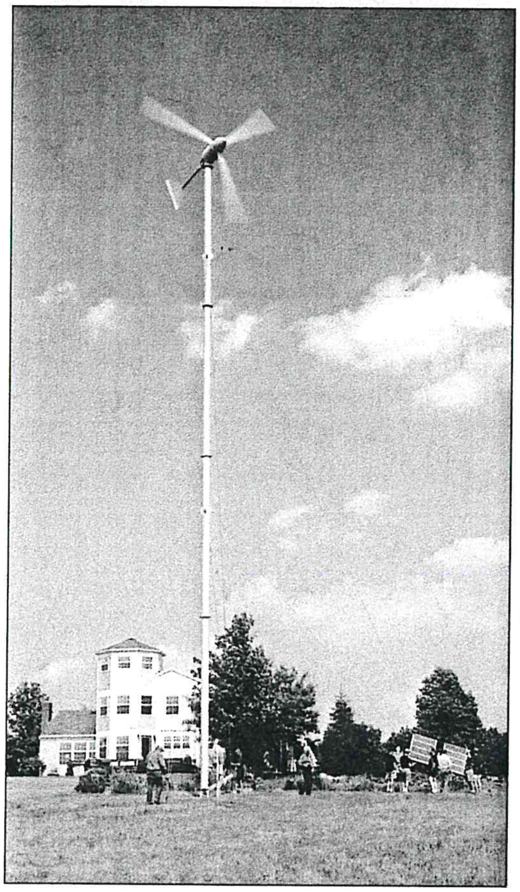
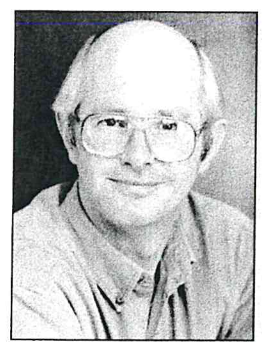
Paul P. Craig, Professor Emeritus of Engineering, University of California at Davis; Chairman, Sierra Club National Energy Committee, 2000–2003



Wind energy today is a booming worldwide industry. The technology has truly come of age, with better, more reliable machinery and a greater understanding of how and where wind power makes sense—from the independent homestead to the grid-connected utility-wide perspective. Heightened concerns about our ravaged environment and our dependence on dwindling fossil fuels have stimulated a resurgence of interest in wind energy—an abundant and renewable resource.

Wind Power is a completely revised and expanded edition of Paul Gipe's definitive 1993 book, *Wind Power for Home and Business.* In addition to expanded sections on gauging wind resources and siting wind turbines, this edition includes new examples and case studies of successful wind systems, international sources for new and used equipment, and hundreds of color photographs and illustrations.



The World Renewable Energy Congress named PAUL GIPE a "pioneer in renewable energy" in 1998. Since the mid-1970s, Gipe's award-winning research, writing, and advocacy have had a profound impact on the development and public perception of wind power. He is also the author of *Wind Energy Basics* (Chelsea Green, 1999) and *Wind Energy Comes of Age.* He lives in Bakersfield, California.

Chelsea Green Publishing
White River Junction, Vermont
802-295-6300
www.chelseagreen.com

ISBN 1-931498-14-8
55000
9 781931 498142

Cover photographs by Paul Gipe • Cover design by Peter Holm

13

Siting

High winds blow on high hills.
—Thomas Fuller, Gnomologia

North American farmers, ranchers, and rural residents should encounter few barriers to erecting wind turbines of any size on their property. Siting in these circumstances is often simply finding the most exposed place for the wind turbine. Problems can arise in suburban and more densely populated areas, where some neighbors may not share your enthusiasm for wind energy. With care, consideration, and a good measure of patience, you should be able to allay any neighbor's concerns. Nevertheless, you should always make an honest appraisal of your site. You may find it unsuitable for wind energy because of physical constraints—too many trees and tall buildings, for example—or because of legal restrictions on how you can use your land.

In this chapter we look first at the physical restrictions on where you can place a wind turbine, then at the more complex topic of institutional restrictions that may limit or even prohibit the use of a wind turbine. The treatment here of the thorny issue of wind turbine siting is far from exhaustive. Entire books are devoted solely to aesthetics or noise. (See the bibliography for details on *Wind Power in View* and *Wind Turbine Noise*.)

Physical Restrictions

Is your site suited for a wind turbine? That's the first and foremost question. Do you have enough room? There must be not only sufficient space for the tower itself, but also enough space to install it safely. And as I've stated, putting the turbine on the roof is not a suitable option.

Wind turbines will not work for everyone, everywhere. But wind turbines, both large and small, are used in surprising places. Guyed towers for small turbines have been installed on city lots so small that the anchors have been placed in each corner of the backyard. Freestanding towers have been installed in equally cramped quarters; on occasion a crane has been required to lift the tower over the house and set it on the foundation.

Europeans, accustomed to greater population densities than are common in North America, are more tolerant of placing wind turbines in proximity to homes, businesses, and public places (see figure 13-1, Sidewalk siting). Commercial-scale wind turbines have been installed in parks, playgrounds, and parking lots, near soccer fields, and at busy truck stops and lock gates. They can also be found alongside canals, dikes, and breakwaters. In Germany it's common to see wind turbines lining the autobahn, while in Denmark rail passengers can watch wind turbines spinning in fields adjacent to the tracks.

Why not put them 5 miles north of Rugby and up Hywy 3?

With only 50-70 acres impacted by the project and 46,000 acres, why in this beautiful area across from Wolford Road (Hywy 17)?

Please refer to Power Point Page 16

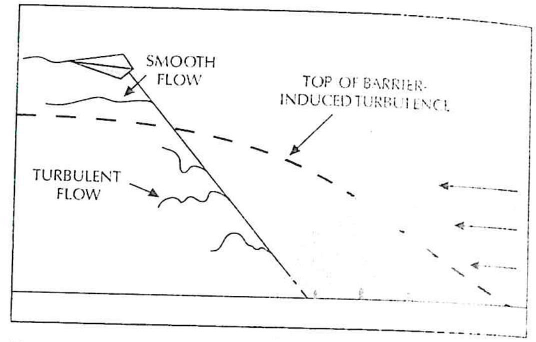


Figure 13-2. Go fly a kite. Trailing streamers from a kite is a simple yet effective way of detecting turbulence. (Battelle PNL)

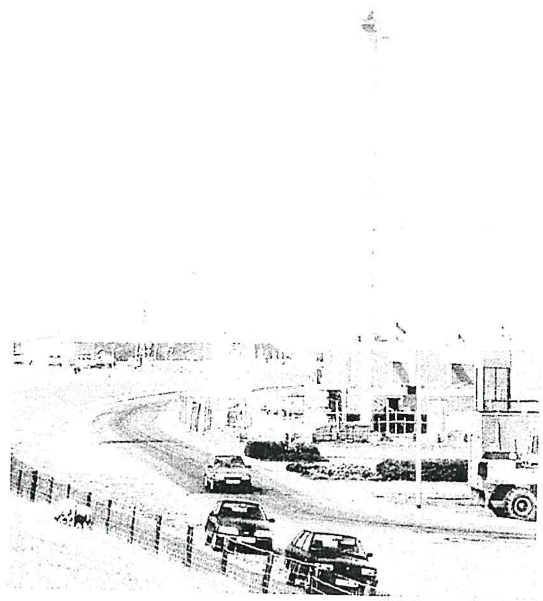


Figure 13-1. Sidewalk siting. A Lagerwey 18/80 next to a fish processing plant along a frontage road in the port of Lauersoog, the Netherlands. The Dutch are accustomed to multiple use of their limited land area.

Yet there are limits, and it's wise to know what they are. Bergey Windpower, for example, recommends at least 1 acre (0.5 hectare) for its Excel model. Smaller turbines may need less.

Exposure and Turbulence

Wind turbines should always be located as far away from trees, buildings, and other obstructions as possible in order to minimize the effect of turbulence and maximize exposure to the wind.

Turbulence, rapid change in wind speed and direction, is caused by the wake from buildings and trees in the wind's path, and resembles the eddies swirling around a rock in a stream. Being buffeted by turbulence can be damaging to modern wind turbines because they use long slender blades traveling at high speeds. Turbulence can wreak havoc on a wind machine, rapidly shortening its life.

In Germany it's common to see wind turbines lining the autobahn.

Buildings and trees also drastically reduce the energy available to a wind turbine. One overriding lesson that has been gleaned from nearly three decades of working with modern wind turbines is that you can't overlook the effect of obstructions, whether buildings or vegetation. Though seemingly less a barrier to the wind than a building, trees, shrubs, and even low hedgerows can rob energy from the wind. It's for this reason that wind turbines are being installed on increasingly tall towers, some up to 100 meters (330 ft) in height.

When you're uncertain about the amount of turbulence over your site—go fly a kite. Tie streamers to the kite string and note how they flutter in the wind (see figure 13-2, Go fly a kite). It's a practical means of seeing the invisible—the swirls and eddies caused by obstructions—and a good way to learn firsthand about turbulence.

Locate the tower far enough either upwind or downwind to avoid the turbulent zone around nearby obstructions (see figure 13-3, Zone of disturbed flow). When this is impractical, use as tall a tower as possible to elevate the wind machine above the turbulence. If neither approach alone is sufficient, use some combination of siting and a taller tower.

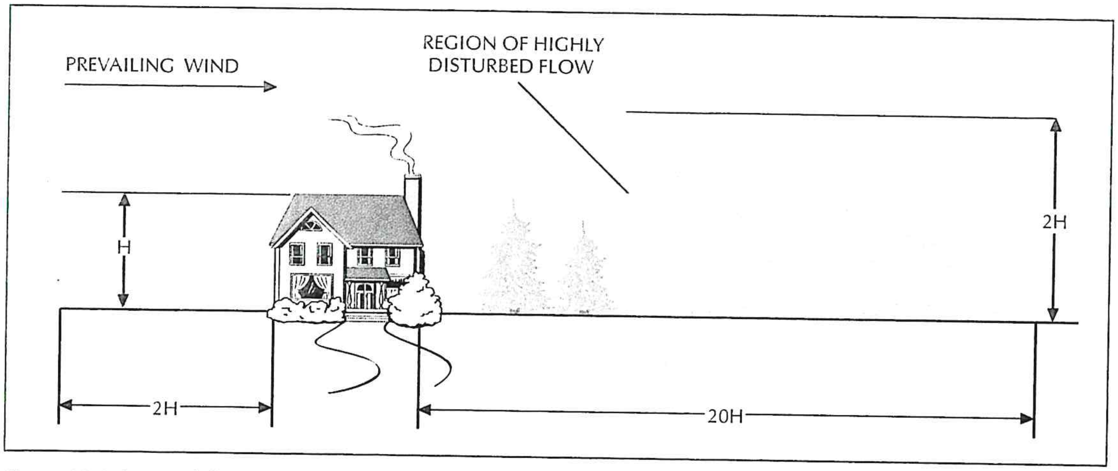


Figure 13-3. Zone of disturbed flow. Wind speeds decrease and turbulence increases in the vicinity of obstructions. The effects are most pronounced downwind but also occur upwind as the air piles up in front of the obstruction. The flow over a hedgerow or group of trees in a shelter belt is disturbed in a similar manner.

From years of experience, small wind turbine manufacturers, consultants, and users have derived a general rule of thumb: The entire rotor disk of the turbine should be least 30 feet (10 m) above any obstruction within 300 feet (100 m). If you've determined, for example, that a group of trees along a fencerow are 60 feet (18 m) tall, you'll need at least a 90-foot (27 m) tower (see figure 13-4, Clear of obstructions). To ensure the best performance, you should use an even taller tower.

The minimum tower height for medium-size turbines is equal to the turbine's rotor diameter. As mentioned previously, many are installed on taller towers. In forested areas of Germany it's not rare for the tower to exceed one and a half times the rotor diameter.

By all means avoid sites at the bottoms of creeks, draws, or ravines and at the bases of hills. If there's a hill on your property with a well-exposed summit, site the wind machine there instead of lower on the slope, even if the summit is some distance from where you plan to use the electricity.

Figure 13-4. Clear of obstructions. This Bergey 850 stands well above nearby willow trees at the Wulf Test Field in California's Tehachapi Pass. Raising small wind turbines above nearby obstructions is the single most effective way to increase performance.

Power-Cable Routing

Once you've selected the area where the tower will be erected, note how the power will be delivered to your load. At this stage you need to anticipate any problems that may develop

Property Values

Evidence that wind turbines affect property values one way or the other has been hard to come by. There was a cursory survey by a real estate agent of land sales near wind turbines in California's Tehachapi Pass. In this survey values actually increased in the vicinity of the wind farms. Why this happened is less clear. But property changed hands at higher values after the wind turbines went in than before. In one case property values increased surprisingly when agricultural land was developed for a mobile home park with a clear view of the wind turbines. In a Wisconsin survey of land sales near two operating wind farms, properties less than 1 mile (1.7 km) from the turbines traded at 141 percent of their assessed value, rising along with other land values in the area. The wind turbines didn't appear to have any negative effect.

The most extensive study in North America was conducted by the Renewable Energy Policy Project (REPP). This study examined property transactions near wind turbines at multiple sites in California, Iowa, and Minnesota, as well as sites in several other states. Altogether REPP evaluated more than 25,000 real estate transactions. After accounting for comparable sales outside the viewshed of the wind farms selected, defined as beyond 5 miles (8 km) from the turbines, the study found that viewshed property generally increased in value faster than property with no view of the wind turbines. REPP's report, "The Effect of Wind Development on Local Property Values," can be downloaded from the nonprofit group's Web site at www.repp.org.

later. They're easier to avoid than to solve. For example, a buried telephone line crossing your path may complicate digging a trench for laying the cable underground. Ideally the electric service from the wind machine will enter the building near where the utility's lines also enter.

In the past it was common for installers of small wind turbines to string the power cables on poles just like those of the electric utility. The consensus today is to bury all conductors, whether for a small or medium-size wind turbine. If the service entrance and meter are on the other side of the building from where you are planning to erect the tower, what is the best route for the laying the power cables to the service entrance? Are there any sidewalks, driveways, or roads in your path? How will you cross them? These are important questions, because the answers affect the cost of installing the wind system. They also determine how difficult it will be to meet certain institutional restrictions, such as the National Electrical Code in the United States.

Institutional Restrictions

Equally as important as finding the optimal site for the wind system is determining what legal requirements your local community places on structures such as wind turbines. In the United States land-use zoning, building codes, and protective covenants may all apply.

Planning Permission

Many who have installed small wind turbines in North America have had few problems, if any, with land-use restrictions. Either their property was not covered by regulations, or where it was permission was quickly and easily obtained. Many rural areas are not zoned at all, and where they are there are practically no restrictions on land that is zoned agricultural. The situation changes as you near cities, small towns, and residential neighborhoods. There the right to swing your fist ends where your neighbor's nose begins.

In some rural locales, wind turbines are specifically permitted unless there is an overriding reason to prohibit their use. In California's Kern County, for example, the use of wind energy is permitted in certain designated agricultural areas. Recently adopted state laws prohibit discriminating against the use of wind turbines relative to other similar land uses.

In most countries, planning approval (or more broadly, the placing of restrictions on how land is used) is a responsibility entrusted to local governments by the public to protect general health and welfare. Officials will want you to show how your use conforms to the public's general agreement on what can and can't be done on land within a designated area.

Public officials have a moral and often legal obligation to treat you fairly. Above all, planning officials shouldn't discriminate against you because they're unfamiliar with wind turbines. Treat them cordially. One thing is certain: If you need a building permit, a zoning variance, or another form of planning approval, you want them on your side.

Building Permits

Where planning ordinances apply, you must conform to the law—period. Find out what the requirements are in your area by calling the local building inspector, board of supervisors, or planning office. You want to know how to obtain a building permit (where required) and who is responsible for issuing it (usually the building inspector). Get details. Whoever is responsible should provide a list of what you must do: the forms to fill out, the fees to pay, where and when to file, and any other information that you must supply. Then methodically deliver what's required.

The intent of this process is to determine conformance with the regulations governing your locale and to alert the public to your project. Whether you want to install 1 wind turbine or 100, take the initiative and contact anyone who might be affected, especially your neighbors. You have a responsibility to tell them what you're planning and why. Speak to them early in the project so that they feel consulted, rather than pressured into backing you. It's much better to talk with them informally over the back fence than in court or in a shouting match at a public hearing. If you get along well, there should be few problems, but if you've driven over your neighbor's prize rosebush for years, you'd better make amends. Objecting to your building permit is a great opportunity to even the score. You can head off conflict by respecting the needs of your neighbors. Treat them in the same way you would like them to treat you.

We will be 100% negatively affected.

At a minimum you will be required to produce a plan or map showing the dimensions of your site and where the tower will be located. You can prepare this yourself. Drawings of the wind turbine, tower, and foundation with their specifications may also be required. The dealer or manufacturer can supply these.

Planning laws follow one of two approaches. One allows you to do whatever you want, unless specifically prohibited. The other approach prohibits you from erecting any structure unless it is specifically permitted. Where the latter approach is used, your application could be denied simply because no one has ever installed a wind turbine before.

In communities where this is the situation, you can sometimes get permission for a wind machine by bringing it under a permitted category such as radio or cell phone towers, TV antennas, or chimneys. Building officials may be empowered to make such a determination. If not, formal action before a public board is necessary. These officals must determine if your use conforms with the intent of the ordinance. Where it doesn't, or where the ordinance specifically excludes wind turbines or similar structures, you must obtain a variance from the regulation.

In the United States the zoning appeals board or board of adjustment is the final arbiter of permit approval disputes. This is a political body, and if there's a public outcry it'll respond accordingly within the limits of the law. Variances—variations from the law—give the zoning appeals board flexibility in meeting local planning objectives: the protection of the common good without undue restrictions. The board members will want to

We were absolutely ignored by the PPM company.

know whether your wind turbine detracts from your neighbors' use of their land, lowers the value of surrounding property, or endangers passersby. The burden of proof is on you, the petitioner.

Frequently the granting of a variance is little more than a formality. You may not even need to be present. But if the board has questions that you have not answered previously, or if the variance is contested, you'll need to be present and you'll need to be well prepared. On occasion unfamiliarity with wind turbines—even today—will fuel wild speculation about what they will do to the neighborhood. Often these fears can be quickly dispelled with the facts. Sometimes they can't. When contested, the public hearing can take on the appearance of an expensive courtroom battle, with opponents bringing in their own "expert witnesses" to counter your assertions. It can be rough—even humiliating—if you're unprepared, or if the hearing officers lose control of the meeting.

You have a right to a fair and impartial hearing. You also have a right to argue your case without intimidation—physical or verbal. Public meetings can quickly degenerate into mob rule if public officials and meeting organizers don't limit disruptive behavior. You have an obligation to stem rumors by immediately responding to wild or outlandish claims. Insist on proof or documentation of unsubstantiated charges. The list of real or potential problems wind turbines might cause can be endless, limited only by the human imagination. Hearing officers have an obligation to maintain civility. If they can't—or, worse, won't—hold them responsible.

In suburban housing developments or planned communities, deeds may contain restrictions, or covenants, on how the land can be used. These restrictions are intended to preserve the identity of the neighborhood. Take a look at your deed. Or call your attorney, realtor, or mortgage company for information. If there are any restrictions, these people will know how best to deal with them. For example, the restrictions may be unenforceable.

Also note the location of any easements on your property for utility rights-of-way. In the United States, easements transfer use of the land without transferring outright ownership. Easements are commonly used for a host of public purposes: power lines, underground telephone cables, pipelines, future roads or sidewalks, and so on. These could all limit your use of the land. You may be unable to encroach on these easements with your wind turbine even though you own the land, there are no restrictive covenants, and you obtained all the proper planning approvals.

Building officials are sometimes bewildered by a request to install a wind turbine. California's San Luis Obispo County officials demanded engineering calculations to assure them that Jim Davis's $1,000 wind system wouldn't pose a hazard to the public. Those calculations would have cost Davis a whopping $5,000 if the wind turbine manufacturer, Southwest Windpower, hadn't faxed him an 11-page document that satisfied authorities.

Bergey Windpower's Mike Bergey likens the permit approval process in some states to "medieval torture." Some projects have taken seven months to obtain a permit, says Bergey—far longer than the time needed to build, ship, and install the turbine.

Through experience, other building officials know what they need to ensure that wind turbines are installed properly. Jonathan Herr, for example, didn't have any problem winning approval to install an Air 403 in California's trendsetting Sonoma County. "I got the building permit over the counter," he says.

Height Restrictions

The most frequent limitation on the use of small wind turbines is a restriction on the height of the tower. In most residential areas of North America, there's a limit to the height of structures, usually 35 feet (11 m), a relic of the days when fire brigades had to pump water by hand. Variances to such ordinances can be obtained by pointing out other structures taller than the limit that have been allowed under the zoning ordinance: radio towers, chimneys, or utility poles. (Local officials seldom have control over utilities.)

When wind farm developers or users of medium-size wind turbines are hampered by such archaic restrictions, they can afford the legal assistance needed to change the law. Those wanting to use small wind turbines often are unwilling or financially unable to fight such height limitations.

In Great Britain some rural residents simply opt for a short tower to avoid the cost and the all-too-frequent controversy surrounding a request to install an appropriate-size tower. Similarly, North Americans also sometimes opt for the path of least resistance. NREL's Jim Green documented one case where the application for a permit to use a tower taller than the 35-foot limit cost more than the wind turbine. This may explain why Green found in a survey of six small wind installations in Colorado that "every wind turbine I saw could have benefited from being on a taller tower."

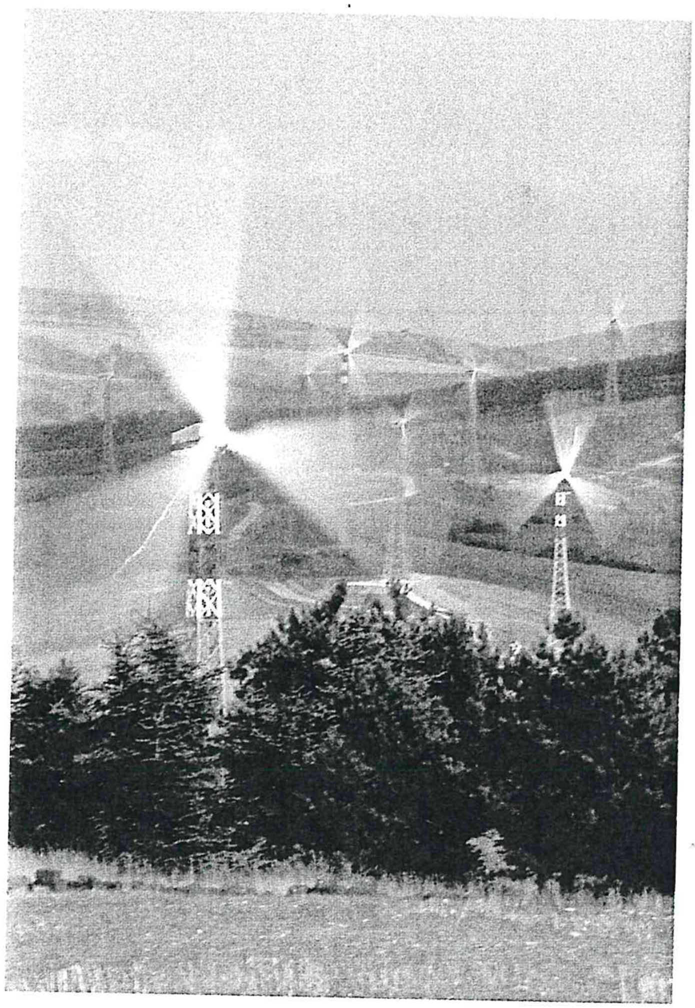


Figure 13-5. Obstruction marking. Italian authorities required obstruction marking of the towers (bands of red and white) on these Vestas V44 turbines above Montefalcone di Val Fortere, northeast of Naples, to alert pilots to the turbines' presence.

Obstruction Marking

In the United States when the height of the tower plus one blade length exceeds 200 feet (84 m), or you're within 1 mile (1.7 km) of an airport, you must register your plans with the Federal Aviation Administration (FAA). This allows the FAA to note an obstruction to aviation on maps and alert pilots to the hazard.

Small wind turbines normally operate well below this threshold, and no permit is needed. If there is any doubt about the need for obstruction marking, building officials may forward a notification to the FAA or advise you to do so as a precaution.

Still, medium-size wind turbines and megawatt-class turbines are being installed on increasingly tall towers that exceed this threshold. To grant a permit the FAA will require the use of a high-intensity flashing white light, or will require you to paint obstruction markings in red and white on the blades, tower, or both. Most of the very tall turbines in North America use flashing white lights. In daytime these lights are aesthetically preferable to the red-and-white banding seen on tall structures near airports, but they detract from the night sky, especially in western North America where there are few other light sources but the stars themselves.

This is the destruction of our landscape and the literary reason of why we moved to North Dakota.

Europe features a considerably higher

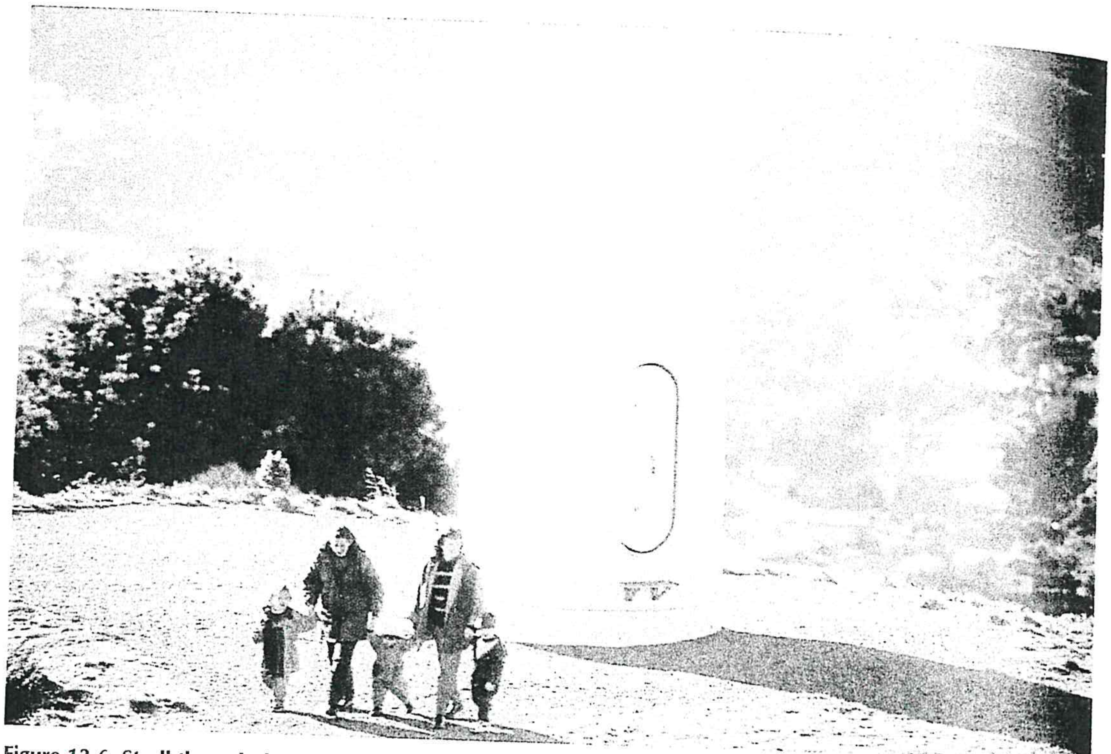


Figure 13-6. Stroll through the park. In this unstaged photo, mothers take their children for a stroll through a park above the village of Brooklyn within urban Wellington, New Zealand. The tower supports a Vestas V27, a 225 kW wind turbine. This particular turbine has consistently been one of the most productive in the world.

height threshold—100 meters (328 ft)—before action is required. Even so, regulations differ from one country to the next. Italy, reacting to the tragic collision of a low-flying U.S. Marine Corps fighter jet with a ski lift gondola full of skiers, has required obstruction marking of relatively short towers on ridgetops in the Apennines (see figure 13-5, Obstruction marking). Tall turbines in Germany are required to have obstruction markings only on the rotor blades. Early megawatt-size turbines in Germany incorporated a series of red-and-white-alternating bands on the blades. Later turbines use only one red band on the outer third of the blade.

No passerby has ever been injured or killed by a wind turbine.

Public Safety

The public has a legitimate interest in the safety of wind turbines and the hazards they may pose. There's no point in hiding the fact that several men have been killed while working on or around wind turbines. And one parachutist was killed on her first unassisted jump when she drifted into a wind turbine on the German island of Fehrmarn. But no passerby has ever been injured or killed by a wind turbine.

Wind turbines, like any large, rotating machinery, should be treated with respect, but there is no reason to fear them unduly. In many parts of the world, wind turbines are part of the community and found in public places (see figure 13-6, Stroll through the park).

In some communities in North America, towers must be set back from the property line a distance equal to their height. Officials reason that if the tower fell over it would not extend beyond the user's property and present a hazard to neighbors. If your lot is too small to permit this, you may want to reconsider wind power. Unfortunately this restriction

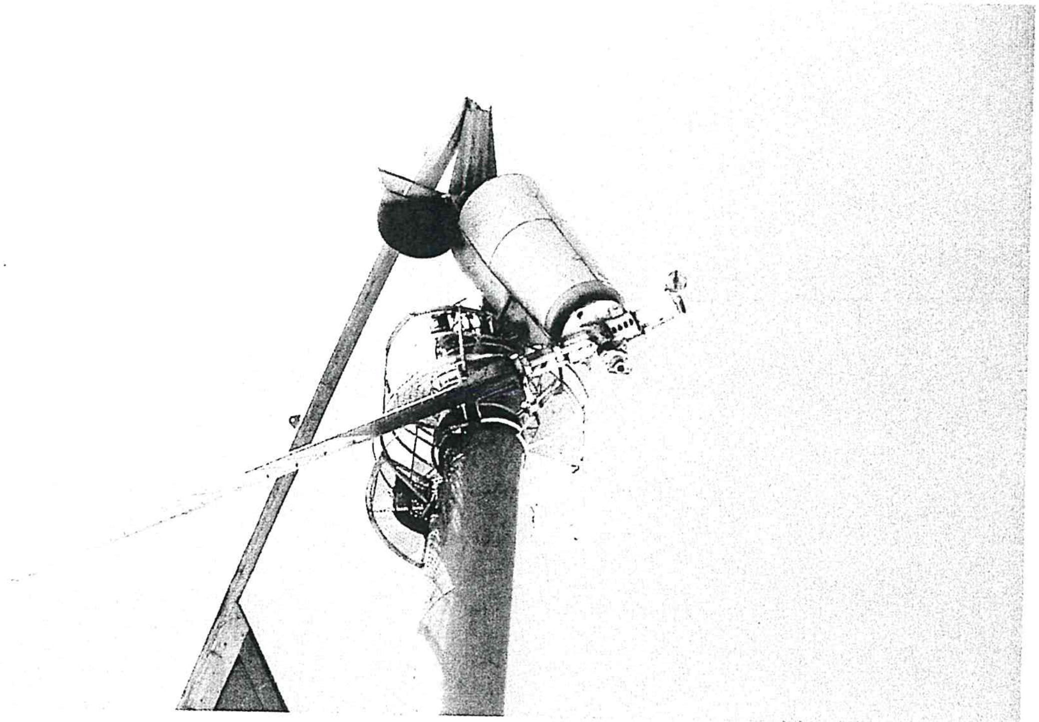


Figure 13-7. A Swiss watch it was not. Twenty years ago wind turbines were much less reliable than they are today. While it was uncommon even then for a wind turbine to destroy itself, some did. This Swiss Wenco operated only briefly before failing in California's Tehachapi Pass. All similar turbines were eventually removed after a complaint by the Sierra Club that they were an eyesore.

discriminates against wind turbines compared to other common structures.

We think nothing of other human-made and natural hazards that pose a risk similar to if not greater than that of a wind turbine. We've all seen homes sheltered beneath the branches of an old oak tree, where occasionally a storm-weakened limb crashes down onto the roof. We accept this hazard as the price we pay for the benefits the tree provides—shade and visual amenity).

The same is true for radio and television towers. In many ways they are similar to towers for wind machines. They are made of metal and extend visually above the roofline. The public has grown to accept them, and because their failure rate is so low, users often install them adjacent to occupied buildings.

Permitting authorities will be concerned that your tower could collapse. You must show them that the tower meets international standards for wind turbine design and applicable building codes, and that similar towers operate throughout your locale in a host of severe environments without incident. Though towers have failed, the occurrence is rare and far less frequent than that of falling trees or utility poles.

Falling Blades

Authorities will also be concerned that the wind turbine could throw a blade or, worse, fling itself off the tower. While infrequent, neither of these is unknown (see figure 13-7, A Swiss watch it was not). Once again, you must convince planning officials that the wind machine has been designed and built to accepted international standards and that there's little likelihood that it will throw a blade into the midst of a neighbor's lawn party.

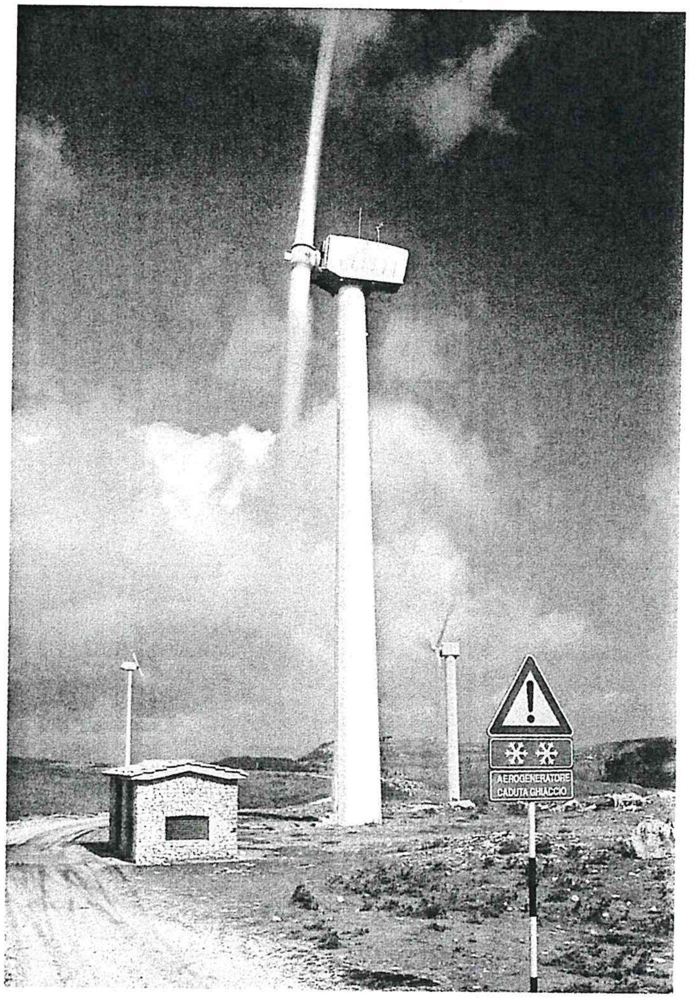


Figure 13-8. Watch for ice. This sign at the Acqua Spruzza test site in Italy's Apennine Mountains warns, WIND TURBINE, WATCH FOR ICE. Europeans typically urge caution around wind turbines, but seldom exclude the public. In this case falling ice could be a hazard, but only during winter storms when few people are likely to visit the windswept site. Note that the roof and facade of the control building are constucted of native materials as used on similar structures elsewhere in this region.

You can best reassure officials that your wind turbine won't become airborne by citing the number of like turbines operating elsewhere and the number of years these turbines have operated without incident. Thus it behooves you to select a wind system with a proven track record: one where a host of units have operated reliably in a variety of applications for several years. If you plan to install a new, untested, or experimental wind turbine, expect authorities to demand more restrictive setbacks than for wind turbines in widespread use.

Falling Ice

A related question in cold climates is ice throw. Under certain conditions, often during cold winter nights when the wind turbine is becalmed, ice can build up on the blades. During the day sunlight warms the ice, loosening it so that the slightest motion sets the ice moving down the blade (see figure 13-8, Watch for ice). Occasionally, as at the 600 kW turbine outside the Bruce nuclear power station at Kincardine, Ontario, the turbine will throw the ice some distance. While no one has ever been injured by falling ice, it's prudent to discourage people from walking near the turbine during ice storms or shortly thereafter.

Ice is a common and accepted hazard in cities with severe winters, such as Montreal, Quebec. In such cities buildings have provisions for breaking rooftop ice sheets into pieces to minimize the hazards they pose when they eventually slide off. Similarly, some medium-size wind turbines destined for northern climes are constructed with heated blades that shed ice as it forms, so that it doesn't become a hazard.

Attractive Nuisance

The fear that a wind turbine could become an attractive nuisance—that is, attract the attention of vandals or children—is unique to North America. Generally a property owner is not liable for accidents to trespassers, but a different test is applied to the acts of children.

Swimming pools are thought to entice or attract children to trespass. Because children cannot discern the hazard presented by the pool, the community views it as a public nuisance, and if an accident occurs, a court can hold the owner liable. Permitting regulations allow attractive nuisances when they have met requirements designed to prevent accidents. Swimming pools must be fenced, for

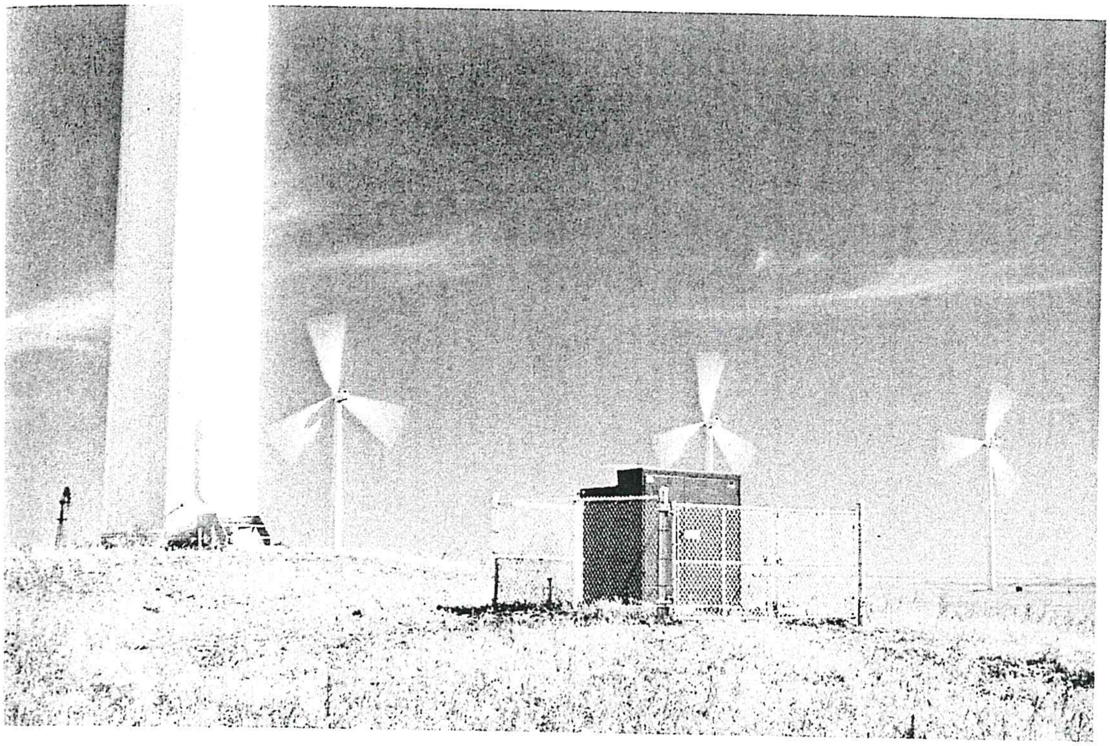


Figure 13-9. Fencing unnecessary. Fencing of this transformer at a wind power plant in Colorado is unnecessary and detracts from the aesthetically pleasing array of wind turbines. Note that the tower is not fenced. The heavy door is locked.

example. The same ordinance may require that towers, such as wind turbine towers, be fenced as well.

Fencing isn't the only way to prevent someone from climbing a wind turbine tower. Electric utilities seldom use fencing. On their transmission towers they simply remove the climbing rungs to a level 10 feet (3 m) or more above the ground. You can do the same on a freestanding truss tower. Or you can wrap the base of a guyed lattice tower in sheet metal or wire mesh. These alternatives should be acceptable to planning officials because they accomplish the same goal as fencing while being less obtrusive. Utilities seldom erect fences around their utility poles or transmission towers. Imagine the outcry if every utility pole required a fence.

Medium-size wind turbines on tubular towers have no need of a fence to prevent unauthorized entry (see figure 13-9, Fencing unnecessary). The massive doors to these towers are securely locked. No child or common vandal could climb these towers. Of the thousands of wind turbines operating in Europe, nearly all are fence-free. Fencing of tall structures to thwart access by children and vandals is a peculiarly American phenomenon.

Avoid fencing wherever possible. Fencing increases the aesthetic impact of wind turbines by drawing unwarranted attention to the turbine with the message, *I am dangerous; stay away.* Or the equally offensive, *This is my wind turbine. Keep your hands off.* In the Tehachapi Pass, unfortunately, wind farm operators do both. They shield their wind turbines behind barbed wire and post signs that say KEEP OUT.

Aesthetics

Fences are just one facet of whether a wind turbine becomes a respected member of the community—or an unwelcome intruder. For some the appearance of a wind machine on the skyline is symbolic of responsible stewardship—a step toward a sustainable future. To others it's

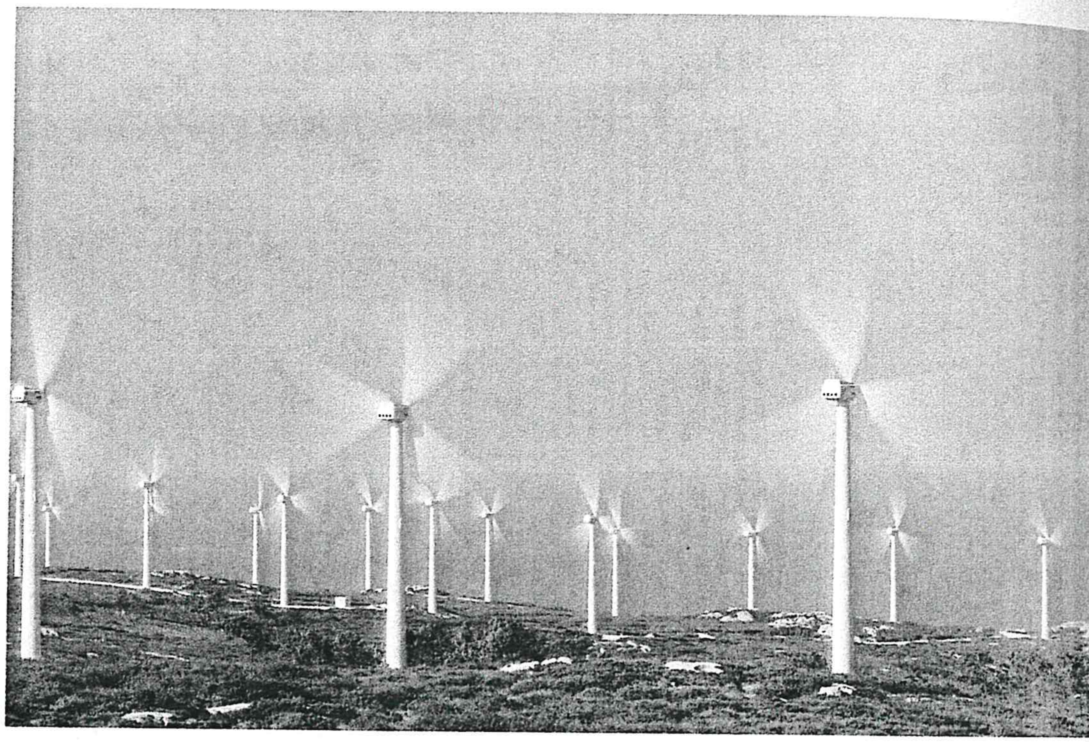


Figure 13-10. Visual uniformity. This pleasing array of Ecotecnia turbines on Spain's Galician coast near Malpica is partly attributable to the visual uniformity of the turbines.

industrial blight and a call to arms. Concern about the visual effect wind machines may have on a landscape and the communities of which they are a part should not be dismissed lightly.

Much has been written about the place of wind turbines in the landscape and how to minimize their visual intrusion. For more on the topic, see *Wind Energy Comes of Age, Wind Power in View,* and *Wind Turbines and the Landscape.* What follows are some general guidelines. Most fall under the rubric of "Be a good neighbor."

Medium-Size Turbines

While medium-size and larger wind turbines are installed as single units, like small wind turbines, more often they're installed in clusters or large arrays—wind farms. When there are more than one or two turbines in visual proximity to each other, it is critical to provide visual uniformity of turbine, tower, color, and direction of rotation. This is the single most important step planners can take to successfully integrate wind turbines into the community. The turbines need not be identical, but they must appear similar (see figure 13-10, Visual uniformity).

As with any business, some wind projects succeed and some fail (see figure 13-11, Headless horsemen). The community has a right to demand that operators repair or replace any "headless horsemen"—towers without turbines on top. If the turbine is not returned to operation, then the turbine, tower, and support equipment should be promptly removed, and the site restored to its pre-project state.

Avoid visual clutter by designing arrays with open spacing. Don't place the turbines too close together. One Tehachapi wind farm operator placed his turbines so close together that their rotors tangled and the turbines had to be repaired, then moved.

There are already too many billboards littering the countryside. Wind turbines

Figure 13-11. **Headless horsemen.** Dead and dying Windmaster turbines on a wind farm in California's Altamont Pass. When wind turbines are no longer "used and useful," they and their supporting infrastructure should be promptly removed.

shouldn't contribute to this visual blight. Don't paint billboards or corporate logos on the tower or nacelle, and specify that the manufacturer provide a nacelle free of corporate advertising. The logo on the side of Vestas's turbines is the size of tractor trailer, but the company will provide the nacelles logo-free—when requested (see figure 13-12, Logo-free).

Bury all intra-project power lines and the transmission lines leading to the project site. Aboveground power and transmission lines at large wind projects detract from the otherwise rural character of the landscape, giving such projects an industrial feel (see figure 13-13, Bury power lines).

Always dress the turbine properly. Some manufacturers, such as Atlantic Orient, are so intent on cutting costs that they will sell and install wind turbines without nose cones (spinners) or nacelle covers. These wind turbines appear angular, mechanical, and, in a word, *industrial*. They say to neighbors, *We don't care what you think*. Similarly, some

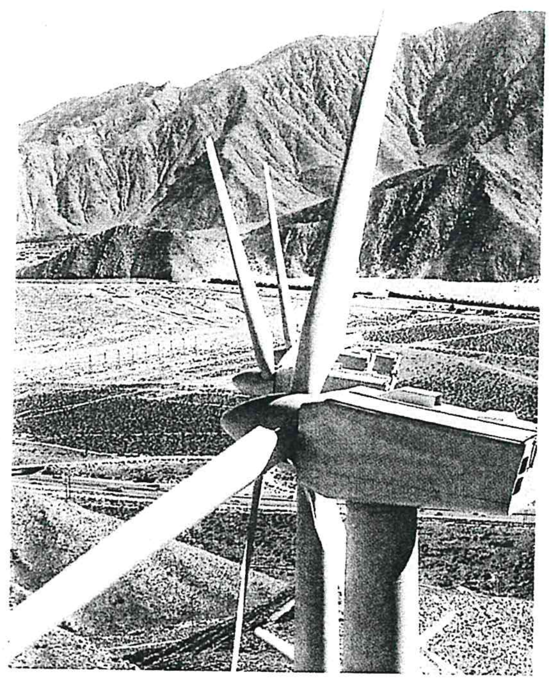


Figure 13-12. Logo-free. Corporate logos on the sides of wind turbine nacelles are an unnecessary visual distraction from their clean lines. Riverside County prohibits logos on wind turbines, as here on Vestas's V27s near Palm Springs, California.

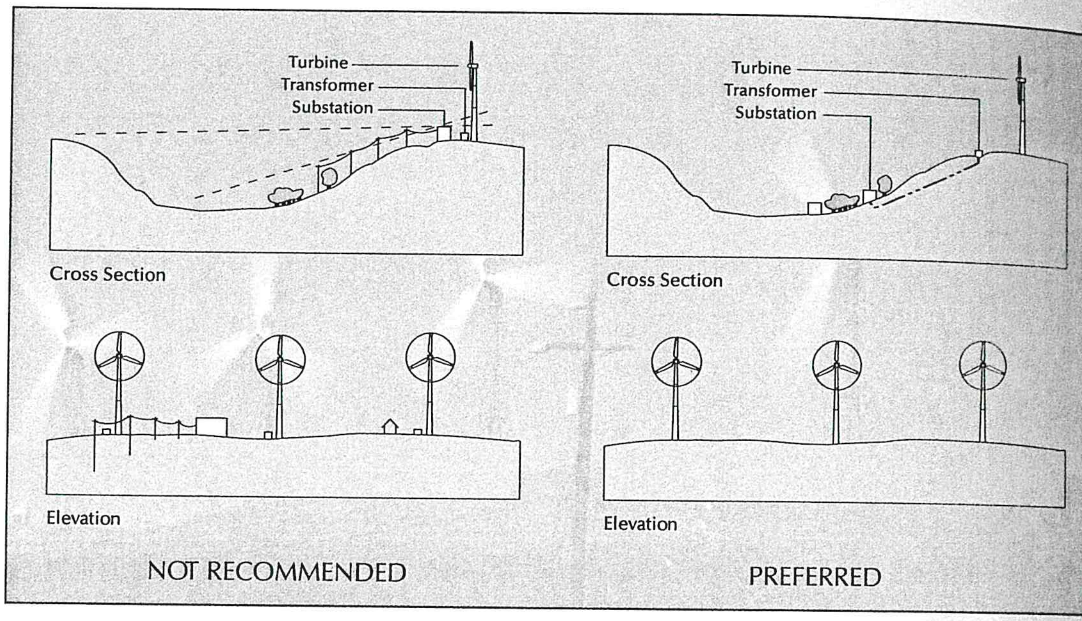


Figure 13-13. Bury power lines. Minimize visual intrusion by burying power lines and removing all ancillary structures from among the wind turbines. Where possible, place transformers inside the tubular towers often used on medium-size and larger turbines. (Chris Blandford Associates)

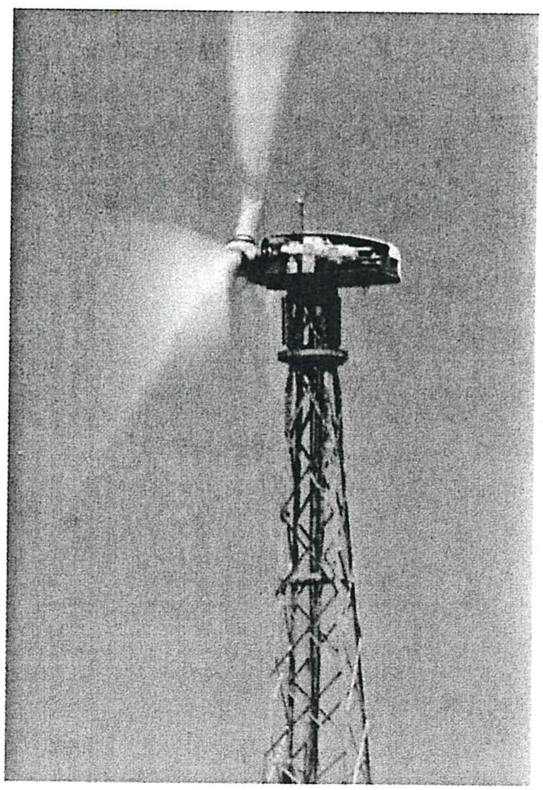


Figure 13-14. Dress turbines properly. A Kenetech KVS 33 operates in the San Gorgonio Pass without a portion of its nacelle cover. Kenetech (U.S. Windpower) turbines were notorious for losing their nacelle covers, which were seldom replaced.

California wind farm operators, in a misguided drive to squeeze every last cent out of aging turbines, remove the nose cones and nacelle covers or fail to replace them when they blow off (see figure 13-14, Dress turbines properly). Turbines in such projects become "junkyards in the sky," fueling wind energy's detractors.

Control erosion by minimizing or eliminating road construction, especially in steep or arid terrain. Too many unnecessarily wide roads can give an otherwise well-designed wind project the appearance of a mining site, instead of the pastoral scene wind advocates envision for the technology (see figure 13-15, Control erosion).

Harmonize ancillary structures with other structures on the landscape. Ancillary structures on a wind project should blend in with their surroundings. At the Italian test site of Acqua Spruzza, control and transformer buildings were built to resemble other rural buildings (see figure 13-8, Watch for ice). When Zilkha Renewable Energy needed an office building and maintenance shop for its Top of Iowa wind plant, it could have chosen a typical

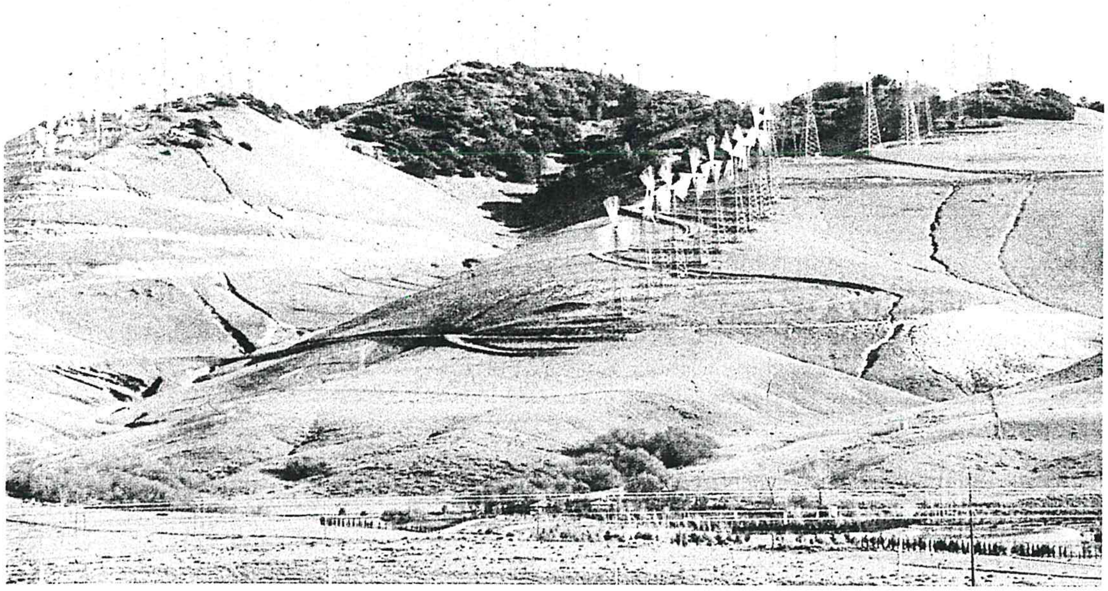


Figure 13-15. **Control erosion.** Erosion gullies from excessive road construction in the steep, arid terrain of California's Tehachapi Pass give wind energy a black eye.

slab-sided metal building. Instead it took an abandoned barn and adapted it to company needs. The barn was more in keeping with other nearby farm buildings, Zilkha decided, than the industrial structure it would have used. Similarly, transformers should be placed inside the tower; where that's not feasible they should incorporate a facade that obscures their industrial features (see figure 13-16, Architectural transformer treatment).

Operators of wind projects should pick up any litter on their sites and eliminate on-site storage of spare parts, damaged wind turbines, oil drums, and other industrial detritus. Trash and litter quickly make a pastoral array of clean, modern wind turbines into an industrial site that just happens to use wind machines (see figure 13-17, Remove litter and boneyards).

Small Turbines

Manufacturers of small wind turbines have paid far less attention to aesthetic design than

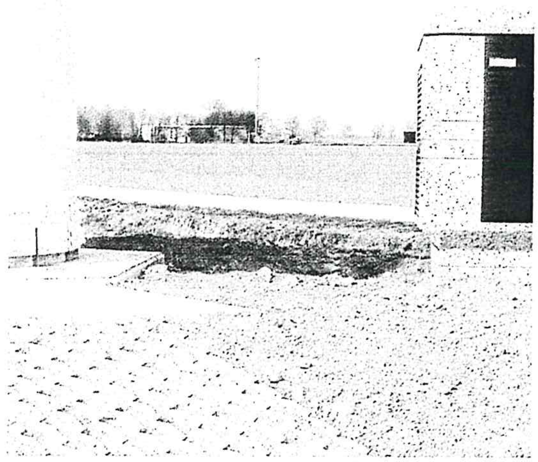


Figure 13-16. Architectural transformer treatment. Where transformers cannot be placed inside the tower, transformers should be shrouded with an architectural treatment. The transformer on the right incorporates a facade to harmonize what otherwise would be an industrial structure with other nearby structures on the landscape. Open-cell concrete pavers harden the access track to the NEG-Micon tower on the left, allowing rain to percolate through to the groundwater table. This turbine and the Lagerwey 18/80 in the background are owned and operated by Noud de Schutter, a Dutch farmer in the Wieringemeer polder north of Amsterdam.

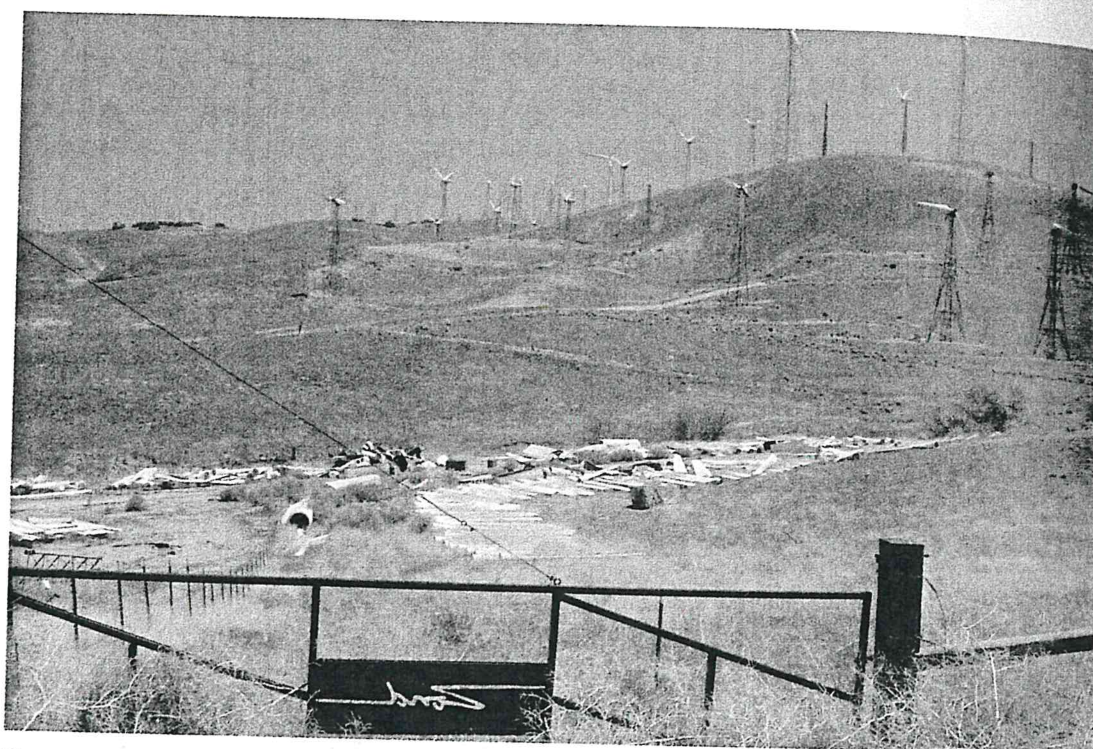


Figure 13-17. Remove litter and boneyards. Discarded wind turbines, blades, gearboxes, and other debris litter the former Zond site in the Tehachapi Pass. Some of the abandoned turbines in the background have since been removed.

manufacturers of larger turbines. Some small turbines are crude contraptions that a reasonable person may not want in the neighborhood. One, the 1980s Jacobs, is an ungainly design that looks like it came directly from a 1930s machine shop, which it did. Many manufacturers of small turbines could use a good industrial designer.

Try to incorporate the community's wishes when you're considering the type of tower to use. There's much less objection to the clean lines of a tapered tubular tower than to a wooden utility pole. Likewise, a tubular tower is more pleasing in foreground views than a truss tower. However, truss and lattice towers should be considered. In distant views, guyed lattice towers and truss towers become nearly invisible. From an aesthetic perspective, the type of tower that's most acceptable (whether truss, guyed lattice, or tubular) depends on the viewpoint and the distance between the observer and the tower. There are no definitive aesthetic guidelines for small wind turbines. (There are for wind power plants, but the two applications are quite different.)

If someone objects on aesthetic grounds, point out similar structures on the horizon that we've learned to tolerate, if not accept. You have as much right to erect a wind machine as the local radio station has to install a tower or the utility has to string a transmission line across town. While it's true that the utility's power lines and the radio's broadcast tower provide communitywide benefits, each person benefits individually. Your installation of a wind system differs little from the utility building a power line to your house. The appearance may differ, but the purpose remains the same.

Don't overlook some obvious ways to adapt the turbine to the community's or your own tastes. Patrick Campbell is a Kern County firefighter who has operated his Bergey Excel since 1998. Campbell is the type of customer who knows what he wants. And what he wanted was a wind turbine that matched the color of his home. Bergey Windpower obliged and painted the turbine to match. "Any customer can request it," says Campbell, but few do.

Avoid garishness. Don't string lights from your turbine for any reason. Be respectful of your neighbors and of the night sky. It's our common heritage to be enjoyed by all.

Noise

Like the appearance of a wind turbine and its placement in the landscape, noise is another frequent community concern. This concern is fueled in part by old reports of noisy wind turbines that were installed in California's San Gorgonio Pass during the early 1980s or by the giant General Electric turbine that operated briefly—very briefly—near Boone, North Carolina. The wind turbines that were the source of the problem are long gone, and manufacturers of medium-size wind turbines have made great strides in reducing noise. That's the good news.

The bad news is that manufacturers of small wind turbines began addressing the problem long after manufacturers of medium-size turbines, and only after some customers—and their customers' neighbors—complained. One model, Southwest Windpower's Air 403, was particularly notorious, though other brands were equally at fault. Fortunately manufacturers of small turbines are finally heeding customer demand for quieter products.

Noise is especially critical to siting small wind turbines because, as Carl Brothers, manager of Canada's Atlantic Wind Test Site, notes, "the smaller they are, the closer they are likely to be placed near someone's house." Mick Sagrillo, one of the founders of the Midwest Renewable Energy Fair, says, "Noise has a lot to do with acceptability." According to the outspoken Sagrillo, the public's occasional wariness toward small turbines could swiftly shift to outright prohibition if noise isn't addressed.

Despite all the technological progress, no operating wind machine is or will ever be silent. Wind turbines are audible to people nearby. Whether it's "noisy" or not is far more difficult to determine. Wind turbine noise is a field where the technical and the subjective meet head-on.

Noise, unlike visual intrusion, is measurable. And because noise is measurable, neighbors will "transfer" their concern about wind energy's aesthetic impact to the increase in background noise attributable to wind turbines. If wind turbines are unwanted for other reasons, such as their impact on the landscape, noise serves as the lightning rod for disaffection.

All wind turbines create unwanted sound, or noise. Some do so to a greater degree than others. And the sounds they produce—the swish of blades through the air, the whir of gears inside the transmission, and the hum of the generator—are typically foreign to the rural settings where wind turbines are most often used. These sounds are not physiologically unhealthful; they do not damage hearing, for example. Nor do they interfere with normal activities, such as quietly talking

Did PPM get Pierce County to drop its' noise restrictions?

Anti-Wind Groups

There are organized anti-wind groups in most countries. These groups are distinct from and should not be confused with environmental organizations that may have legitimate concerns about the impact of large wind projects. Environmental organizations generally support the use of wind energy, though they may object to specific projects. Anti-wind groups oppose all wind energy for political or cultural reasons. Some of these groups are well funded, sophisticated, and utterly ruthless. While their ire is generally directed at wind farms, their broadsides don't make distinctions. They paint all wind turbines (large and small), all projects (big and little), and all wind turbine users (individual and corporate) with the same brush. These groups share information electronically. So don't be surprised if someone steps to the podium at a public hearing in Pipestone, Minnesota, and starts talking about wind turbines in Ryd-y-Groes, Wales, or the Causse du Larzac in France.

to your neighbor. But the sounds are new, and they are different.

Those who live in the rural settings where wind turbines are best suited do so because they prefer the peace and quiet of the country to the noise of the city. Longtime residents are accustomed to the relative quiet of rural life. They are familiar with the noises that exist, and have learned to live with them or even to find them desirable: the wind in the trees, the chirping of birds, the creaking of a nearby farm windmill, the hum of the neighbor's tractor. Rather than being nuisances, these sounds reinforce the bucolic sensation of living in the country.

The addition of new sounds, which most residents have had little or no part in creating and from which they receive no direct benefit, can be disturbing. No matter how insignificant they may be in a technical sense, these new sounds signify an outsider's intrusion. The effect is magnified when the source, such as a wind turbine, is also highly visible.

There are plans for more turbines to come down our road (6 mile marker) off Hgwy 17 *

Decibels

First, some background. Noise is measured in decibels (dB). The decibel scale spans the range from the threshold of hearing to the threshold of pain (see table 13-1, Typical Sound Pressure Levels in dBA). Further, the scale is logarithmic, not linear. Doubling the power of the noise source—say, by installing two wind turbines instead of one—increases the noise level only 3 dB. This alone causes more confusion about noise than any other aspect, because a change of 3 dB is the smallest change most people can detect. Tripling the acoustic energy increases sound level 5 dB, an increase that is clearly noticeable. It takes 10 times the acoustic energy to raise the noise level 10 dB and double its intensity, or sound twice as loud.

For most discrete sources, such as wind machines, the distance to the listener is just as important as the noise level of the source. As in table 13-1, whenever noise is presented as

Table 13-1
Typical Sound Pressure Levels in dBA

Source	Distance from the Source (ft)	(m)	dBA
Threshold of pain			140
Ship siren	100	30	130
Jet engine	200	61	120
Jackhammer			100
Freight train	100	30	70
Vacuum cleaner	10	3	70
Freeway	100	30	70
Large transformer	200	61	55
Wind in trees	40	12	55
Light traffic	100	30	50
Average home			50
Quiet rural area at night			35
Soft whisper	5	2	30
Sound studio/quiet bedroom			20
Threshold of hearing			0

sound pressure levels (SPL), the location is always specified, or implied, because sound levels decrease with increasing distance.

Weighting Scales

The perceived loudness varies not only with the sound level but also with the frequency, or pitch. Human hearing detects high-pitched sounds more readily than those low in pitch. The sound of a complex machine such as a wind turbine is composed of sounds from many sources, including the swoosh of the wind over the blades and the whir of the generator. Each source has a characteristic pitch, giving the composite sound a characteristic tonal quality. When measuring noise we try to take into account the way the human ear perceives pitch by using a scale weighted for those frequencies we hear best. The A scale is most commonly used. This scale ignores inaudible frequencies and emphasizes those that are most noticeable.

What about our dogs?

Impulsive sounds, those that rise sharply and fall just as quickly—like a sonic boom, for example—elicit a greater response than sounds at a constant level over time. Wind machines using two blades spinning downwind of the tower emit a characteristic *whop-whop* as the blades pass through the turbulent wake behind the tower. This impulsive sound and its effect on those nearby may be missed by standard A-weighted measurements. Many of the complaints about wind turbine noise near Palm Springs in the early 1980s were directed at the impulsive noise from two-blade, downwind turbines. Noise containing pure tones or impulsive sounds is perceived as louder than broadband noise. Broadband noise, such as the aerodynamic noise from the wind rushing over a turbine's blades, is composed of sounds across the spectrum of human frequency response. It is less intrusive than either impulsive noise or noise with distinct tonal components.

Exceedance Levels

Another component of noise is time. Noise ordinances specify a noise level that must not be exceeded during a certain percentage of the time. This complicates the task of estimating a wind turbine's noise impact. Unlike trains or airplanes, which emit high levels infrequently throughout the day, a wind turbine may emit far less noise, but do so continuously for days on end. Some find this trait of wind energy more annoying than any other. In windy regions the sound may appear incessant. The literature of life on the Great Plains is full of references to the ever-present sound of the wind. In the classic 1928 film *The Wind*, the sod-busting pioneer played by silent-screen star Lillian Gish is driven mad by the oppressive wind.

The time-weighting of noise is expressed as the noise exceedance level: the amount of time the noise exceeds a specified value. For example, L_{10} is the noise level exceeded 10 percent of the time; L_{90}, the noise level exceeded 90 percent of the time; and L_{eq}, the continuous sound pressure level, which gives the same energy as a varying sound level. A noise standard of 45 dBA L_{90} is stricter than a standard of L_{10}, because 90 percent of the time the noise must be below 45 dBA (see table 13-2, Selected Noise Limits, Sound Pressure Levels in dBA). Wind turbine noise emissions are measured in L_{eq} in order to calculate the sound power generated by the turbine.

Noise Propagation

Noise levels decrease with increasing distance as the sound propagates away from the source. Under ideal conditions sound radiates spherically from a point source, such as a helicopter, and for every doubling of distance the noise level decreases 6 dB. Wind turbines, however, seldom hover high above the ground like a balloon. They are earthbound, and their noise emissions spread outward hemispherically.

There are seven sloughs nearby our home.

Over a flat reflective surface such as a lake, noise decays 3 to 6 dB per doubling of distance. The atmosphere and objects on the landscape absorb some of the noise energy, further attenuating the noise over distance. The International Energy Agency (IEA) assumes hemispherical spreading in its commonly used noise propagation model. This simple model also incorporates a modest amount of atmospheric absorption.

More complex noise propagation models account for ground cover and meteorological effects. Both can greatly influence noise levels. Temperature and wind shear, for example, refract or bend sound waves from those expected, and vegetation can attenuate or absorb more sound than the IEA model assumes.

The rate at which noise decays increases with increasing atmospheric absorption. Relatively close to the tower, within 100 to 200 meters (300 to 600 ft), atmospheric absorption has little effect. As distance increases—for example, from 200 to 400 meters (600 to 1,300 ft)—the decay rate with absorption increases to 7 dB with every doubling of distance. Thus the noise attenuated by atmospheric absorption can be important

Table 13-2
Selected Noise Limits, Sound Pressure Levels in dBA

		Commercial	Mixed	Residential	Rural
Germany					
Day		65	60	55	50
Night		50	45	40	35
Netherlands					
Day	L_{eq}		50	45	40
Night			40	35	30
Denmark[1]	L_{eq}			40	45
England[2]					
High speed	L_{50}				45
Low speed	L_{50}				40
Minnesota					
Day	L_{50}	75	65	60	60
Night	L_{50}	75	65	50	50
Minnesota					
Day	L_{10}	80	70	65	65
Night	L_{10}	80	70	55	55
Kern County, Calif.[3]	$L_{8.3}$			45	45
Riverside County, Calif.	L_{90}			45	
Palm Springs, Calif.[4]	L_{90}			50	60

Notes: [1] Not to exceed 45 dBA beyond 400 m from wind turbine.
[2] L_{50} approx. 350 m from the nearest turbine.
[3] $L_{8.3}$, not to exceed 50 dBA.
[4] 50 dBA if lot is actually used as residential.

in projecting noise levels surrounding a wind turbine.

Unfortunately meteorological effects vary with the season, weather patterns, and time of day. Vegetation may vary seasonally, as well. Row crops may be tilled in fall when deciduous trees also lose their leaves, removing much of the vegetation that dampens noise from nearby turbines. Moreover, nighttime temperature inversions refract sound waves, bending them back to earth, increasing the noise level over that estimated by simple models. Valley inversions during fall and winter produce a similar effect. Anyone living alongside a lake or river has experienced sound carrying great distances during wintertime inversions.

There is also little or no atmospheric absorption of extremely low-frequency sound. For these reasons, engineers are hesitant to incorporate greater atmospheric absorption into their noise propagation models. Thus the models remain conservative.

Our dogs?

Again, there will be more turbines on our road.

Multiple wind turbines complicate matters further. From relatively long distances, an array of turbines appears as a point source, and doubling the number of turbines simply doubles the acoustic power increasing noise levels 3 dB. As you near the turbines, they begin to act as a line source. The decay rate for line sources is 3 dB per doubling of distance, and not 6 dB for true spherical propagation.

Help! Please refer to photos.

Even the wind itself will influence how noise propagates. Noise levels are typically higher downwind of turbines, and even higher for downwind turbines.

Thus estimating the noise emitted by a single wind turbine or a large array is no simple matter and is fraught with uncertainty. Though noise, unlike aesthetic impact, is quantifiable, interpreting the results of field measurements and mathematical projections requires almost as much subjective judgment as it does objective analysis.

One can only suppose that the reason why PPM rowed the farmers not to tell anyone especially the newspaper was- because they do not want this information to get out!

Ambient Noise

The total perceived noise is the logarithmic sum of the ambient or background noise and the projected wind turbine noise. Thus the noise generated by a wind turbine must always be placed within the context of other noises around it. Wind turbines near busy highways will hardly create a problem, no matter how noisy they are, though the noise from the wind turbine may still be identifiable above the background noise. Conversely, wind turbines, no matter how quiet, may be heard above ambient noise at great distances in the stillness of a sheltered mountain cove.

The wind itself often masks wind turbine noise by raising the ambient noise level. At exposed locations there will always be noise from the wind whenever the wind machine is operating, because the wind rustles the leaves in nearby trees or sets power lines whistling. Despite the masking effect of high winds, a wind turbine will still be audible to people nearby, particularly when they are sheltered from the wind.

The sounds emitted by wind turbines are easily distinguishable from those of the wind. The generator or transmission may produce a noticeable whine, for example, or the passage of the blades may generate more discrete sounds. The aerodynamic *swish-swish-swish* of three-blade rotors is a common wind turbine sound. These sounds may not be objectionable, but they are detectable. The whir of the compressor in a refrigerator is audible, for example, but few find the sound objectionable. Some have compared this situation to that of a leaky faucet. Once recognized, the noise is hard to ignore.

Where the background noise level is low, as in a deep valley sheltered from the wind, a new noise may be considered intrusive, particularly at night when few other human-made sounds are present or a nighttime temperature inversion has brought a deathly hush to the valley. Whether or not a noise is intrusive depends on the nature of the noise; that is, its tonal or impulse character, the perception of the noise source (whether the wind turbines are loved, despised, or merely tolerated), the distance from the source, and the activity (for example, whether you're sleeping inside with the windows closed or conversing with a neighbor in the yard). But no wind turbine, no matter how quiet, can do better than the ambient noise. It is the difference between ambient noise and wind turbine noise that determines how people react.

Will It Be Heard?

Yes. That's the short answer. If in the heat of a public debate on the noise from a wind turbine or that from a wind farm, resist the temptation to say *It won't be heard.* It will. Avoid the equally false statement *You won't hear it over the wind in the trees.* They will. The characteristic sounds from a wind turbine are distinguishable from the background noise of, for example, the wind in trees at great distances. While the noise may not be objectionable, it can be detectable to those who want to hear it.

Community Noise Standards

Local noise ordinances typically state the acceptable sound pressure levels in dBA at the property line or nearest receptor. Many noise ordinances differentiate between acceptable day and nighttime levels, and levels for sensitive land uses such as schools and hospitals. The noise levels that wind turbines must meet in Europe and the United States are surprisingly similar. Where they differ is in the exceedance levels.

California's Kern County, for example, limits wind turbine noise to 45 dBA at $L_{8.3}$ for sensitive receptors (see table 13-2, Selected Noise Limits, Sound Pressure Levels in dBA). $L_{8.3}$ is the noise level exceeded for five minutes out of every hour. Minnesota has two standards: 50 dBA at night in rural areas at L_{50}, the noise level exceeded half the time; and 55 dBA at L_{10}, the level is exceeded

10 percent of the time, or six minutes out of every hour.

All community noise standards incorporate a penalty for pure tones, typically 5 dB. If a wind turbine meets a 45 dB noise standard, for example, but produces an annoying whine, planning officers dock the offending turbine 5 dB. The operator must then lower the turbine's overall noise level 5 dB or eliminate the whine.

Despite compliance with community noise standards, operators of wind turbines still run the risk of annoying their neighbors. Whenever wind turbine noise exceeds the threshold of perception, there is the potential for complaints. Fluctuations in ambient noise and variations in the quality or tonal component complicate determining whether wind turbine noise will exceed the perception threshold and stimulate complaints (see table 13-3, Community Response to Noise from Sources Other Than Wind Turbines).

If there is a noise complaint public health officers will measure the sound pressure level using a sound level meter and will determine whether the wind turbine complies with the applicable ordinance. This was the situation New Zealand's Graham Chiu found himself in. He received a free noise test courtesy of the Wellington City Council after a neighbor complained about his Air 403. Chiu was found in violation and the noise control officer ordered the turbine shut off—permanently. Violation of the order could cost Chiu as much as NZ $200,000 in fines.

Table 13-3
Community Response to Noise from Sources Other Than Wind Turbines

Amount by which Noise Exceeds Background Level (dB)	Estimated Community Response: Category	Description
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of action
20	Very strong	Vigorous action

Note: This table was derived for noise sources other than wind turbines, and neighbors could be either more or less sensitive to wind turbine noise than that indicated here.

Source: Harvey Hubbard, Kevin Shepherd, NASA, 1990.

As in Chiu's case, violating a noise ordinance can result in serious consequences, including removal of the wind turbine. Though not foolproof, there are mathematical models that can be used to project noise levels before a wind turbine is installed. These models use sound power to project noise levels surrounding a wind turbine.

Sound Power Levels

The International Energy Agency's model, for example, uses the acoustic energy generated by the wind turbine. Acousticians use field measurements of sound pressure levels (SPL), or L_p, to calculate the sound power levels, or L_w, emitted from the wind turbine. As if the similar-sounding names were not confusing enough, both measures use the same units, dBA. While sound pressure levels will always be specified at some distance from the turbine, the sound power level will always be presented at the source: the wind turbine itself.

The distinction is important. The sound power level of most wind turbines varies from 90 dBA to more than 100 dBA. For those familiar with sound pressure levels, this appears noisy. Yet a wind turbine emitting a sound power level of 100 dBA can meet a 45 dBA noise limit in sound pressure level, given sufficient distance from the wind turbine. The sound power level can be found by

$$(L_w) = (L_p - 6\ \text{dB}) + 10 \log (4\pi R^2)$$

where R is the slant distance from the turbine to the sound level meter, L_p is the sound pressure level measured by the meter, and –6dB is a correction to the meter reading to account for using a reflective soundboard (see figure 13-18, Noise measurement of a micro turbine).

Sound power data on many medium-size wind turbines is publicly available, for example in the German Wind Energy Association's annual *Windenergie: Marktübersicht (Market Overlook)*. There was little comparable data on small wind turbines outside Denmark prior to 2002, when data became available from NREL and the Wulf Test Field (see figure 13-19, Measured Air 403 plus ambient noise).

Noise measurements on wind turbines are recorded for two conditions. One condition is the turbine plus ambient; that is, the wind turbine operating as intended. (At the Wulf Test Field, for example, the micro turbines were charging batteries.) Another condition is ambient noise alone, or with the turbine parked. Once the difference between the turbine plus ambient and the ambient noise is determined, the sound power emitted by the wind turbine can be calculated.

For most small wind turbines there are only two conditions: operating and parked. The Air series of micro turbines, for instance, parks the rotor when the batteries are fully charged. Other turbines, such as Southwest Windpower's Whisper H40, divert charging to a dump load, keeping a load on the generator and limiting rotor speed. Bergey Windpower used a different approach on its

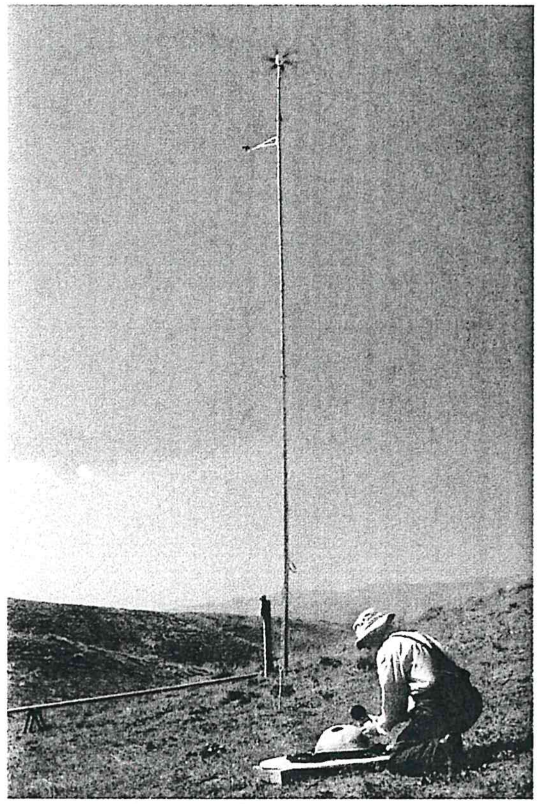


Figure 13-18. Noise measurement of a micro turbine. Beginning a sequence of noise measurements downwind from an Ampair 100 at the Wulf Test Field. The recording sound level meter is being inserted into the secondary windscreen mounted on the reflective soundboard. The sound pressure levels measured by the meter are used to calculate the strength of the noise emitted by the wind turbine.

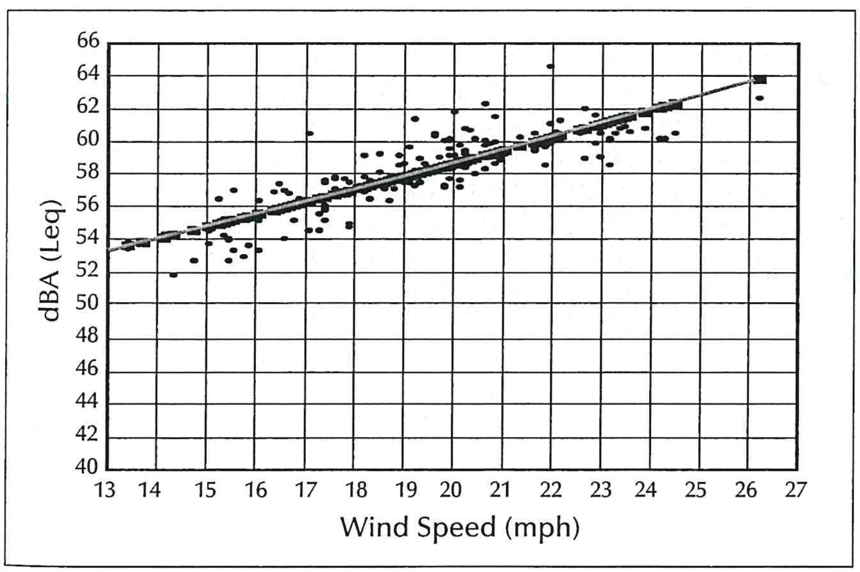


Figure 13-19. Measured Air 403 plus ambient noise. Sound pressure level measurements and linear regression for an Air 403 charging a constant load at the Wulf Test Field. These measurements reflect noise from the turbine plus the ambient noise, not turbine noise alone. This is the first of several steps in determining the noise emitted by a wind turbine. Measurements were made at a slant distance of 19.4 meters (63.6 ft).

Figure 13-20. BWC 850 noise measurement summary. A linear regression of sound pressure level measurements of a Bergey 850 for ambient (turbine parked), charging, and with the turbine operating unloaded. The Bergey 850 unloads the generator when the batteries are fully charged, causing the rotor to spin faster, generating considerably more noise than when charging. Measurements were made at a slant distance of 28.04 meters (92 ft).

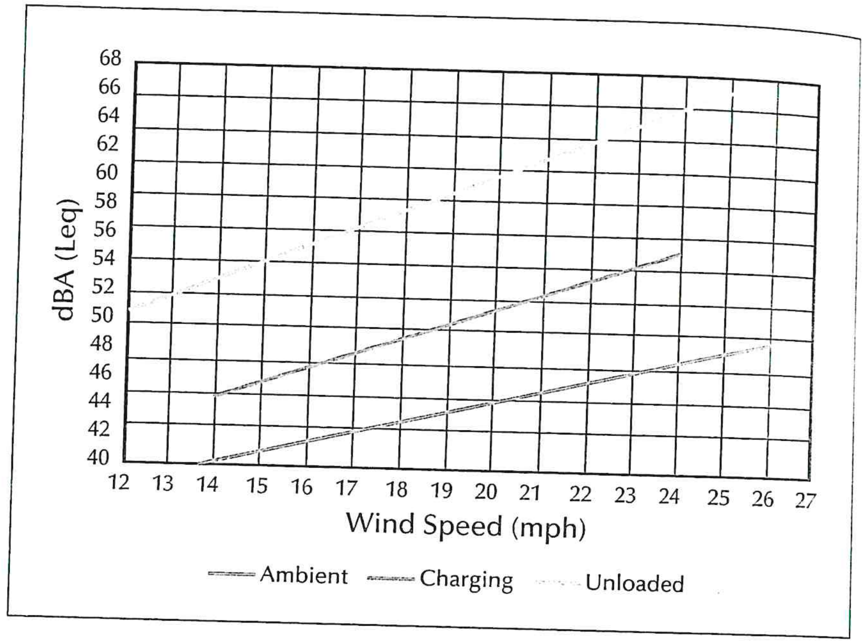


Table 13-4

Comparison of Noise from Small and Selected Medium-Size Wind Turbines

Turbine	Rotor Dia. (m)	Rotor Dia. (ft)	Swept Area (m²)	Rated Power (kW)	Sound Power @ 8 m/s ($L_{WA,\ ref}$)	Sound Power @ 10 m/s ($L_{WA,\ ref}$)	Data Source
Ampair 100	0.91	3	0.66	0.1	na[1]	na[1]	Gipe
Air 403	1.17	4	1.07	0.4	88	91	Gipe
AirX	1.17	4	1.07	0.2	80	na[1]	Gipe
Whisper H40	2.13	7	3.58	0.9	85		NREL
BWC 850	2.44	8	4.67	0.85			
Charging					82	87	Gipe
Unloaded					92	97	Gipe
Calorius	5	16	20	4.6	82		Risø
Gaia	7	23	38	6.5	88		Risø
Genvind	13	41	125	23.7	103		Risø
Furländer	13	43	133	30	93		TÜV
Gaia	13	43	133	11.6	89		Risø
Enercon E30	30	98	707	200	95	99	Wind-consult
Nordex N43	43	141	1452	600	101		Wind-consult
NEG-Micon	60	197	2827	1000	98	101	Windtest KWK
Enercon E66	66	216	3421	1800	101	103	Windtest KWK

Note: [1] Not applicable. Difference between turbine plus ambient and ambient was less than 5 dBA.

850, however. The Bergey 850 unloads the generator when the batteries are charged, releasing the rotor and allowing it to spin faster than when charging. For turbines such as the Bergey 850, then, measurements must reflect all three conditions. The Bergey 850 is noisiest when it operates unloaded (see figure 13-20, BWC 850 noise measurement summary).

To compare one wind turbine's noise to another's, you must derive the sound power level, L_{wa}, for a standard wind speed of 8 m/s (17.9 mph), and often 10 m/s (22.4 mph) as well (see table 13-4, Comparison of Noise

Sources of Small Turbine Noise

Noise from small wind turbines is largely a function of tip speed, blade shape—especially near the tip—and how the turbine regulates power in high winds. Unlike medium-size turbines, many of which operate at constant or near-constant tip speeds, nearly all small turbines operate at variable speeds. As wind speed increases, so does tip speed—and noise.

The Air 403, for example, would reach a tip speed of 90 m/s (200 mph) in winds of 10 m/s (22 mph), nearly twice that of medium-size commercial wind turbines. And the tip speed for the Air 403 would continue to increase until the blades begin to flutter. At that point the noise from the turbine has been described variously as like a hoarse shriek or the buzz of a chain saw. Similarly, when the BWC 850's controller unloaded the generator, the rotor would reach a tip speed of nearly 70 m/s (156 mph). While this may seem modest in comparison to the Air 403, the Bergey pultruded blade was quite different from the saberlike shape of the Air 403 blade and consequently was noisier.

Bergey turbines have used pultruded fiberglass blades since the late 1970s. These blades, while extremely durable, have a thick trailing edge. Jim Tangler, an aerodynamicist at NREL, attributes much of the noise from the older Bergey blades to this thick trailing edge. In contrast, the trailing edge of the Air 403 blade is so sharp, Southwest Windpower warns users to wear gloves when assembling the rotor.

Dave Blittersdorf of NRG Systems operates a Bergey Excel in the backyard of his home near Burlington, Vermont. A keen observer, Blittersdorf noted that the Excel was noisiest when the controller unloaded the rotor, leading to higher tip speeds. To keep the neighbors—and his wife, Jan—happy, he ensures that his turbine always operates under a load.

Wisconsin wind advocate Mick Sagrillo explains that aerodynamic noise can be especially noticeable in small turbines that furl the rotor to limit power in high winds. This behavior differs from one design to another, with a resulting difference in noise emissions.

Bergey turbines, Southwest Windpower's Whisper series, and African Wind Power's design all furl the rotor horizontally toward the tail vane. "There's less furling hysteresis in the AWP design and in the Whisper's angle governor" than in the Bergey line, says Sagrillo, and this is reflected in the noise characteristics of these turbines.

Small turbine manufacturers have heard the message that noise is a subject that won't go away. "Noise is a concern," says Bergey Windpower's Mike Bergey. In response the Oklahoma company has introduced new airfoils to replace the simple cambered blades that were once the hallmarks of the Bergey design. Dave Calley, Southwest Windpower's chief designer, acknowledges that noise was the "absolute number one complaint" about the Air 303 to 403 design. "It's a very important issue to us," says Calley, with the result that Southwest Windpower's AirX is significantly quieter than previous models in the Air series. Small turbines need not be noisy. The "Marlec is remarkably quiet," says Wisconsin's Sagrillo. Among household-size turbines, the 1930s-era Jacobs and the 1980s turbine of the same name were extremely quiet. And, Sagrillo adds, "the AWP and Proven 2500 are every bit as quiet as the Jacobs." What's quiet? To Sagrillo, a wind turbine's quiet "when you have to go outside to see if it's running." He says, "wind generators should be seen, not heard."

What a horrible way to live.

from Small and Selected Medium-Size Wind Turbines). The measurement and reporting techniques designed for medium-size wind turbines may not adequately describe the noise characteristics of small wind turbines. Small turbine noise may be most noticeable at wind speeds other than 8 or 10 m/s.

When the data is available, sound power levels can be calculated for a range of wind speeds (see figure 13-21, Calculated emission source strength). This enables comparisons that otherwise wouldn't be revealed using the standard reporting format. For example, measurements of the Ampair 100 at the Wulf

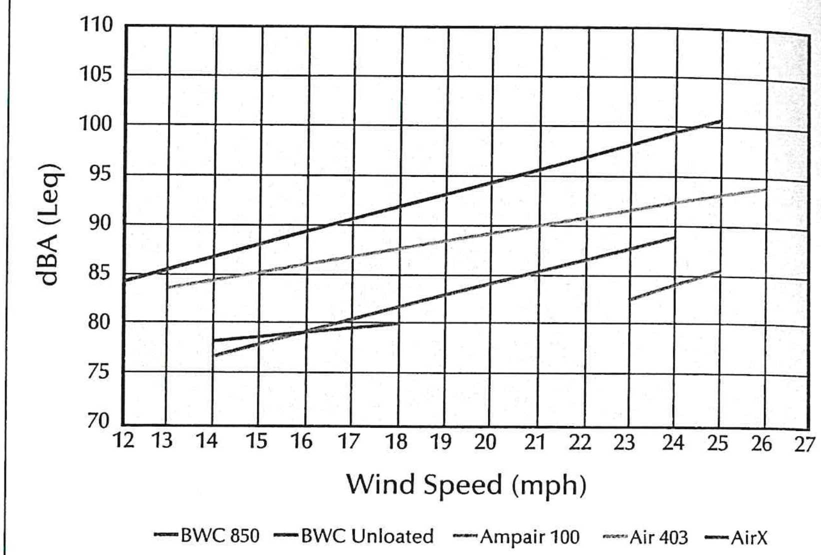


Figure 13-21. Calculated emission source strength. Measured sound pressure level data from the Wulf Test Field on the BWC 850, Air 403, AirX, and Ampair 100 was used to calculate the sound power level or emission source strength (L_{wa}). The sound power level was calculated for each turbine charging a load, as well as for the BWC 850 operating unloaded. As indicated by the Ampair 100, small wind turbines need not be noisy.

Test Field indicated that it was significantly quieter than most other turbines tested at wind speeds above 10 m/s (22.4 mph).

Wind Turbine Noise

There are two sources of wind turbine noise: aerodynamic and mechanical. Aerodynamic noise is produced by the flow of the wind over the blades. Mechanical noise results from the meshing of the gears in the transmission, where used, and the whir of the generator.

Unless there is a whistling effect from slots or holes in the blades, aerodynamic noise is principally a function of tip speed and shape. Aerodynamic noise is also influenced by trailing edge thickness and blade surface finish. The number of blades is also a factor. Neil Kelley, a researcher at the National Renewable Energy Laboratory, finds that the aerodynamic noise of two-blade wind turbines is greater than that of three-blade machines, all else being equal, because the two-blade turbines place higher loads on each blade for an equivalent output. Further, the type of rotor control, whether fixed or variable pitch, affects aerodynamic noise. On rotors with fixed-pitch blades, noise increases when the blades enter stall in high winds. But rotor diameter and speed are the primary determinants of aerodynamic noise. Many constant-speed, medium-size turbines operate at tip speeds around 40 m/s (90 mph) in low winds when their low-power windings are energized, and 50 to 60 m/s (110 to 130 mph) when the generator is fully energized. Some early experimental turbines, operating at variable speed, reached tip speeds of 100 m/s (224 mph).

Dutch researcher Nico van der Borg found that by using rotor diameter as a substitute for tip speed, he could approximate the noise emission of wind turbines. Larger-diameter wind turbines generate proportionally more acoustic energy than smaller machines. Van der Borg's model was derived from data on experimental wind turbines designed in the 1970s and early 1980s. Many of these early research turbines operated at very high tip speeds. Van der Borg compared them to commercial turbines available in the 1980s and estimated that the commercial turbines were as much 7 dB quieter than their predecessors (see figure 13-22, Calculated and measured noise emissions). Later turbines are even quieter.

Van der Borg's model can also be used to answer the question of whether small wind tur-

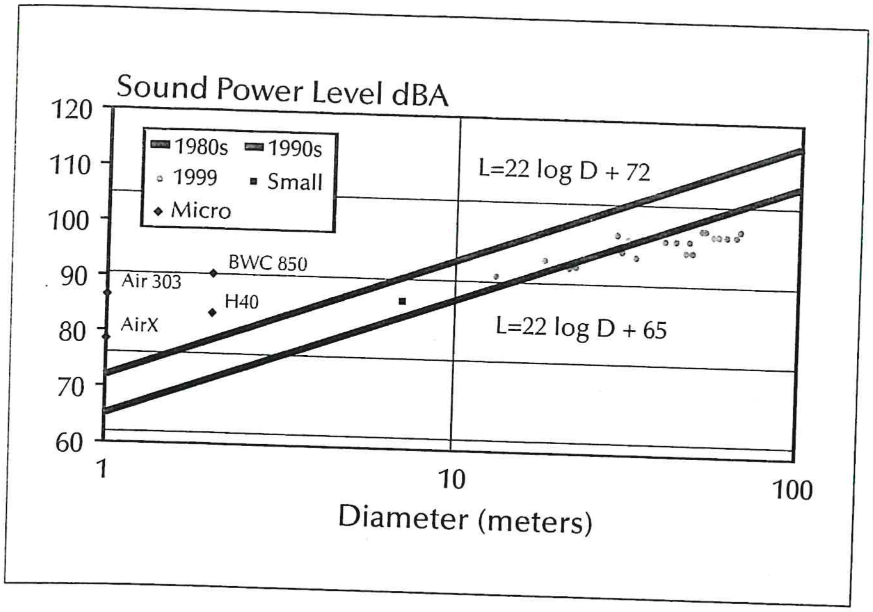


Figure 13-22. Calculated and measured noise emissions. This chart derives from work at ECN by N. C. J. M. van der Borg and W. J. Stam in 1989 on the relationship between source sound power and rotor diameter. Van der Borg and Stam argued that diameter could substitute for tip speed and hence determine sound power. The top line was derived from data on experimental large turbines developed in the late 1970s and early 1980s. The bottom line was derived from data on commercial wind turbines being installed in the late 1980s. Published data for commercial turbines in use from the 1990s through 2000 has been added. Noise emissions from small turbines at the Wulf Test Field and other test sites are also included.

bines are relatively more noisy than bigger turbines. In absolute terms they aren't, but relative to their rotor diameter small wind turbines are noisier. According to van der Borg's model, the Air 403, BWC 850, and Whisper H40 should emit no more than 70 to 80 dBA. Instead the small turbines are 10 to 15 dBA noisier than would be expected for their size. Fortunately manufacturers of small wind turbines have begun to address the issue.

Lowering Wind Turbine Noise

Advances in airfoils and reductions in tip speeds have essentially decoupled noise emissions from rotor diameter for medium-size wind turbines. Building quieter turbines not only makes wind energy a better neighbor, but also makes good business sense. In Europe, where competition is fierce, manufacturers find that quieter turbines give them an edge over their rivals. Manufacturers with quieter turbines can site them in areas where planning officials would prohibit their competition, and quieter turbines ensure that there are fewer headaches after installation, as well as less bad press eroding support for wind energy.

The most direct way to lower noise emissions is to reduce rotor speed. One means of lowering rotor speed on a constant-speed turbine is to operate the turbine at dual speeds. This permits operating the turbine at a lower rotor speed in light winds, when there is less wind noise to mask noise from the turbine. Variable-speed operation is also effective, enabling designers to program operation to lower rotor speeds at night, when noise sensitivity is greatest.

Mechanical noise often has tonal components. The gearbox's high-speed shaft is the most critical element, says Henrik Stiesdal, chief designer for Bonus wind turbines. Mechanical noise can be reduced by redesigning the gearbox and by adding resilient couplings in the drive train to isolate vibrations. Acoustic insulation can also be installed inside the nacelle cover to reduce propagation of mechanical noise.

Stiesdal insists on totally enclosing the drive train and sealing the nacelle canopy. Even ventilation louvers must be carefully designed as sound baffles, he says, or a significant part of the turbine's machinery noise, especially noise at higher frequencies, will escape the nacelle. Stiesdal agrees with NREL acoustician Neil Kelley that noise must be controlled at the source, because "once it gets out, you don't know where it will go."

Consequences

As Graham Chiu found, once noise does get out, the consequences can be costly. One example of the consequences was encountered by Danish manufacturer DanWin. Because of the proximity of one neighbor to a project at Kynby, DanWin took special precautions when building and installing the 21-turbine wind farm. It mounted the 180 kW nacelles on rubber dampers, sharpened the trailing edges of blades on the eight nearest turbines, mounted sand-dampening chambers on four towers, and reduced generator speed to 1,000 rpm from the typical 1,200 rpm.

> If there's any doubt as to whether or not your wind turbine might disturb nearby residents, be a good neighbor and contact them in advance.

Despite these precautions, the noise at the nearest residence, a farmhouse 220 meters (720 ft) away, exceeded permissible levels and included a pure tone component from the gearbox. After four years of work, the turbines' noise emissions were reduced from 97 to 102 to 95 dBA, resulting in an acceptable noise level at the dwelling. DanWin's successors achieved this by redesigning the gear teeth and adding further noise treatment. The engineers found they could gain 4 dBA simply by sharpening the trailing edge of each blade, providing one of the most convincing demonstrations that trailing edge thickness is a significant factor in aerodynamic noise. The cost? DKK $4.5 million ($750,000).

Wisconsin Public Service faced a similar dilemma. After installing 14 Vestas V47 turbines in 1999 the utility began receiving noise complaints from neighbors in Lincoln Township, an area experiencing spillover growth from suburban sprawl east of Green Bay. WPS conducted a series of noise studies and eventually offered to buy six homes. Two homeowners accepted, costing the utility about 2 percent of the project's initial investment.

Neighborhood reaction to small turbine noise can also affect how or when owners use their turbine. As in the case of Chiu in New Zealand, public authorities can order the turbine removed. Equally damning could be an order not to operate the turbine at night or in winds above a certain speed. In either case the operation of the turbines would be so marginalized as to dictate its removal.

The Danish windmill owners' association takes a strong stand on wind turbine noise. The association's members not only are the chief advocates of wind energy in Denmark, but also own most of the wind turbines. Many can literally see wind machines outside their windows. They can speak with authority as people who both want wind energy and demand that it be a good neighbor. Their position is clear: Noisy turbines are unacceptable. Noisy machines should either be soundproofed or moved. The goal of the owners' association, one that should be the goal of all wind turbine manufacturers, is to avoid the problem from the start. They have found that once people have been bothered by noise, they remain disturbed, even after the noise has subsequently been abated.

Consideration

Our perception of what constitutes noise is affected by many subjective factors. If your neighbors object to your wind machine because you never invite them to dinner, they're more likely than you are to find the sound produced by it objectionable. On the other hand, if your community has fought rate increases with the local utility, the sound of your wind machine whirring overhead may warm their hearts.

Bergey Windpower suggests that if there's any doubt as to whether or not your wind turbine might disturb nearby residents, be a good neighbor and contact them in advance. Advise them of your plans, and ask for their comments. Answer their questions as forthrightly as you can, and try to incorporate their concerns when designing your installation. Bergey has found that the community's reaction to the noise from a small wind turbine declines after people have had a chance to acclimate to it.

This is equally sound advice for those installing medium-size wind turbines. Be considerate. Newer, quieter wind turbines can be good neighbors—when sited with care.

TV and Radio Interference

Neighbors sometimes worry that a new wind turbine will disrupt their radio and television reception. There have been a few cases in which medium-size turbines have caused ghosting of weak television signals in rural areas. In one case in the early 1980s, Westinghouse's Mod-0A on Rhode Island's Block Island generated complaints as well as electricity. The problem was alleviated by installing cable television on the island.

Interference is a rare phenomenon, and there have been no reported cases due to small wind turbines. Even in the few cases in which interference or ghosting has been documented, the effects have been localized.

There are thousands of wind turbines lining the ridges of the Tehachapi Pass, a major corridor for telephone links between northern and southern California. The turbines surround the microwave repeater stations but are excluded from the microwave path. This provision is sufficient to prevent any interference.

Small wind turbines are used extensively worldwide to power remote telecommunications stations for both commercial and military uses. The turbines would never have been selected if there had been any hint of interference. Unfortunately some wind turbine operators have sought additional revenue by renting space on their towers for telecom dishes and antennas, a practice that detracts from the appearance of the wind turbine (see figure 13-23, Interference, no; ugly, yes).

Figure 13-23. Interference, no; ugly, yes. Vestas V47 with awkward telecom antennas in Germany. While the wind turbine is obviously not interfering with telecommunications here, the antennas and their mounting hardware give this Vestas turbine an undesirable industrial appearance.

Shadow Flicker and the Disco Effect

Shadow flicker occurs when the blades of the rotor cast shadows that move rapidly across the ground and nearby structures. This shadow can disturb some people in certain situations, such as when the shadow falls across the window of an occupied room.

Small turbines are too small and operate too fast to create a significant shadow. Medium-size wind turbines can cause shadow flicker, however, and it can be a nuisance in higher-latitude winters, when the low angle of the sun casts long shadows. It can also be more troublesome in areas with high population densities or

Shadow Flicker

Many North Americans smile when Europeans begin discussing a phenomenon called shadow flicker. Most Americans have never heard of it and can't imagine what the fuss is about. That was my reaction until one fall when I lived near a 75 kW turbine at the Folkecenter for Renewable Energy in Denmark. One morning while working at my desk I felt uneasy. Something was bothering me. I kept looking up from my work, scanning the room for what was wrong. Finally I got up from my desk. Then I noticed it: a shadow repeatedly crossing the room. It was still a few moments before I realized I was a victim of shadow flicker. I flipped on the light, and went back to work.

Lights on, doors shut, winter, night...!

where neighbors are close enough to be affected by the shadows.

Near Flensburg in Schleswig-Holstein, German researchers examined the effect and found that flicker, under worst-case conditions, would affect neighboring residents a total of 100 minutes per year. Under normal circumstances the turbine in question would produce a flickering shadow only 20 minutes per year.

There are few recorded occurrences of concern about shadow flicker in North America. Ruth Gerath, however, notes that the flickering shadows from the turbines on Cameron Ridge near Tehachapi have startled her horse and those of others in the local equestrian club. Except for the flickering shadows, she says, the turbines seem to have no effect on the horses. The shadows simply cause the horses to stop briefly, until their riders urge them on.

> The charge that wind turbines produce more dead birds than electricity is false.

While few communities have standards regulating shadow flicker, it's wise to be considerate of your neighbors. If there's any question whether nearby residents will be affected, analyze the likely impact before installation.

Professional wind turbine siting software (see the appendixes for details) often includes provisions for calculating shadow flicker. The technique used by these programs is extremely conservative and will project worst-case conditions (bright sun, cloudless sky).

The disco effect is a related phenomenon first noticed in sunny Palm Springs, California. Sunlight glints off the reflective gel coat of the fiberglass blades of the wind turbines in the San Gorgonio Pass. When the blades move, this causes a flash similar to that of a strobe light. As the rotor spins, the flash repeats with a rhythm akin to that of the flashing lights in a discotheque.

To prevent the disco effect from annoying neighbors, Riverside County prohibits reflective blade coatings. The surface finish also dulls after several years in the harsh desert sun, reducing the blades' reflectivity over time.

Birds

Wind energy's chief attribute is its environmental benefits. When sited with care, wind energy is relatively benign. The key is sensitive siting and a frank acknowledgment that wind turbines do have some environmental impact. Though wind turbines have little or no impact on most plants and animals, they can and do kill some birds. Notably, large arrays of medium-size wind turbines have killed birds in the Altamont Pass and near the Straits of Gibraltar. There's no benefit in sugarcoating that fact. Nonetheless, the charge that wind turbines produce more dead birds than electricity is false.

Much has been written about birds and wind turbines. For a more complete account of the problem, see *Wind Energy Comes of Age.* Numerous studies on the topic have been conducted in Europe and North America. Summaries of this research are available from most national wind energy associations.

No single environmental issue pains wind energy advocates more than the effect wind turbines might have on birds. Clearly wind turbines should not kill birds, and we should do everything in our power to ensure that they don't. This is the kind of hot-button issue that elicits strong emotional responses that could, if not addressed honestly, derail the use of wind energy.

That some wind turbines kill birds some of the time should come as no surprise. Most tall structures kill birds to some degree, as do most sources of energy. This should never become an excuse for ignoring the issue, but it does help put it into perspective.

Wind turbines anywhere are capable of killing birds, explains Dick Anderson, a biologist at the California Energy Commission. But nowhere else in the world is the problem as severe as in California's Altamont Pass.

Wind turbines in the Altamont Pass, says Anderson, kill 100 to 300 raptors per year, of which 20 to 50 are golden eagles *(Aquila chrysaetos)*. Golden eagles are a protected species in North America, but are not rare or endangered. While the death of any bird is unfortunate, biologists prefer to place the death in the context of the total population rather than focus on the number of individual deaths, according to Tom Cade, founder of the Peregrine Fund and director of the World Center for Birds of Prey. The deaths, regrettable as they are, "may really have no biological significance," says Cade.

The number of birds killed in the Altamont Pass could be significant for a species, such as the golden eagle, that has suffered population declines throughout its range in California due to urban encroachment. The state's raptors, or birds of prey, are fast losing their habitat to an exploding human population. In the San Joaquin Valley alone, more than 95 percent of wildlife habitat has already been converted to other uses. Consequently wildlife becomes increasingly dependent on the remaining "islands" of undeveloped land. Some of this land remains undeveloped because high winds make it hostile to human habitation. Thus there is the potential for increasing competition between raptors and large-scale wind development for the same resource. The population of golden eagles in the Altamont Pass appears stable, says the CEC's Anderson. The state hasn't yet been able to determine if the number of golden eagles being killed is having a negative effect on the breeding population. Meanwhile, biologists are continuing their fieldwork.

Anderson confirms that wind turbines lining the Tehachapi and San Gorgonio Passes in southern California are also killing raptors, but it's much less of a concern to the state because the numbers killed are significantly lower than those in the Altamont. Fortunately no rare or endangered birds such as bald eagles *(Haliaeetus leucocephalus)*, peregrine falcons *(Falco peregrinus)*, or California condors *(Gymnogyps californianus)* are known to have been killed by wind turbines or their power lines anywhere in California.

Despite the problem among the thousands of medium-size turbines in the Altamont Pass, there's little data on the impact from single medium-size turbines, small clusters of machines, or small wind turbines. It's reasonable to assume that small wind turbines or clusters of larger machines kill birds in proportion to the turbine's size and number. The question of whether small wind turbines also kill birds does arise (see figure 13-24, Birds and small wind turbines).

Consider the case of the Western Pennsylvania Conservancy and Audubon of Western Pennsylvania. They manage a nature center in a Pittsburgh suburb and operate a small wind turbine as part of a display on solar energy. During the mid-1980s they found a dead duck at the base of the tower. Greatly disturbed, they called the dealer. He was speechless. The next day he inspected the wind turbine for any telltale signs. A bird the

Figure 13-24. Birds and small wind turbines. Bird perching on an anemometer boom beneath a Marlec 910F at the Wulf Test Field. As this scene illustrates, small wind turbines are not immune to concerns that they pose a hazard to birds.

size of a duck would have severely damaged the 1 kW Bergey turbine. The dealer found the turbine unscathed.

A few days later a neighbor called the nature center searching for his pet peacock. Meanwhile visitors had begun sighting a fox on the grounds. These reports prompted the center's naturalist to reexamine the dead bird, and the mystery was soon solved. He concluded it was the missing peacock and not a duck, after all. And after finding signs of the fox near the tower, the center concluded that the fox, not the wind turbine, was the culprit.

Still, there are anecdotal reports of collisions between birds and the guy cables of small wind turbines. "Birds collide with just about everything," says NREL's Karin Sinclair. Anytime a structure, whether a house, a skyscraper, or a wind turbine, is raised above ground level, it will pose a hazard to birds; and that includes small wind turbines.

More damaging to wind energy's reputation than the numbers of birds being killed in the Altamont Pass is the manner in which they die. Two-thirds of the golden eagles were killed after colliding with wind turbines or their towers. This lends itself to blaring headlines and self-styled investigative reports revealing the "true story" behind one green technology.

BioSystems, in a report for the California Energy Commission on the problem with wind turbines in the Altamont Pass, tried to put the issue in perspective by noting that 5 to 80 million birds die annually in the United States from collisions with structures ranging from picture windows on homes to cooling towers on power plants.

Birds are killed not only in the production of electricity, but also in its transmission and distribution. Birds die by striking overhead power lines (and telephone lines) or by electrocution. While it's difficult to prevent birds from flying into power lines, most deaths by electrocution are avoidable and can be prevented by modifying transmission line towers.

Ornithologists can only speculate on what happens as birds fly near wind turbines. Flying is hazardous, especially for immature birds. "It's a tricky business to be a fast-flying animal at low altitude," said the University of Pittsburgh's late Melvin Kreithen. "They make mistakes."

The job of the wind industry should be to make flying around wind turbines less hazardous. But there's no panacea or silver bullet for eliminating the problem. Painting splashy stripes on the blades and adding noisemakers have been found wanting. The most effective method is avoiding the problem altogether by siting wind turbines where there are no large concentrations of birds that might collide with the turbines.

Wind companies—large and small—must avoid the fortress mentality evoked by the issue of birds crashing into wind turbines. Some companies respond by trying to control the damage instead of trying to solve the problem. As Exxon found with the *Valdez,* "damage control" may cause as much damage to the company's interests as the disaster itself.

A better approach than damage control is to engage the environmental community before a project is proposed. Environmentalists, including bird lovers, generally support wind energy—when given a chance.

Take Rich Ferguson, for example. Ferguson, energy chair of Sierra Club California, labels the situation in the Altamont Pass "tragic and unacceptable." Nevertheless, he believes the issue is less than black and white and wants to know how many dead birds, specifically golden eagles, are too many? This position doesn't prevent Ferguson from supporting wind energy. When a project was proposed to repower an existing Altamont wind farm with newer turbines, Ferguson urged approval of the project.

One essential step for projects with large numbers of turbines is to study the proposed site beforehand. Ornithologists can determine the level of risk to particular species if the project proceeds. Public authorities and the environmental community must then weigh what risks do exist against the environmental benefits the project provides. Once a large project is in operation, it's also necessary to conduct a postconstruction survey to verify that any impacts are within the range expected.

Though the overall impact on bird populations from wind energy may be slight, the fact that there is an impact at all illustrates, once again, that there are costs to all energy choices. "There's no free lunch," says the CEC's Anderson.

Some birds, including eagles, will fly into wind turbines regardless of mitigation measures. An unpleasant thought, yes. Yet, to some extent, unavoidable. Those who think otherwise are deluding themselves. "Zero kill?" says Tom Cade of the Peregrine Fund. "That's not ever going to happen."

Case Studies

Where it exists, criticism of wind energy results largely from fear of the change this new technology may bring to the community. Just as we grew to accept—and now demand—the utility's intrusion on the landscape, gradually we will grow to accept wind machines, in much the same way and for many of the same reasons.

Though it may fear this technology, the community should not apply more stringent standards to wind machines than it applies to any other similar structure or device now standing. Proponents of wind turbines need not ask for special treatment of wind energy, but they are at least entitled to equal treatment.

Whatever you do, don't bypass the permitting officials. You have a responsibility to comply with the community's wishes, even if you don't agree with them.

In New Cumberland, Pennsylvania, an unthinking homeowner bought a wind machine to install in his backyard. Then, to his chagrin, his application for planning approval was rejected. Not only was wind energy not permitted in his residential neighborhood, but also his lot was physically too small. He hired an attorney and engaged in a lengthy and expensive appeal. His neighbors objected vociferously. Then, amid the glare of television lights and a packed hearing room, his appeal was denied—again. His troubles didn't end there. The dealer then refused to buy back the wind machine and the homeowner had to sell it at a loss. He didn't do his homework, and it cost him dearly.

This unfortunate homeowner can be excused because of his enthusiasm for wind energy and his ignorance of the planning process. The same can't be said for some so-called wind farm developers who have committed similar blunders. The difference is in the sums of money involved: not thousands, as in the homeowner's case, but hundreds of thousands.

One group of self-styled professionals was planning to erect several unreliable wind turbines in a New Jersey residential neighborhood—without planning approval. They were about to begin construction when the local news media broke the story. (There was an exciting mix of New Jersey–style backroom politics involved.) The scheme was quickly killed in a boisterous public hearing.

These cases illustrate how not to install a wind machine. There are literally thousands of examples in which the appropriate approvals have been obtained in an orderly and businesslike manner and the wind turbine successfully installed. Consider the example of an upper-income suburb of Pittsburgh.

Fox Chapel Township has a reputation for strict interpretation of its zoning ordinances. "They'll never let you put one here," some said. Yet the dealer, Bill Hopwood of Springhouse Energy Systems, and the client, the Western Pennsylvania Conservancy, were both respected and thoroughly prepared. (They had to receive approval to erect their anemometer, so they were familiar with the process.) They answered all questions forthrightly, allayed the fears of planning officials, and, to the surprise of cynics, won approval. The wind machine, a Bergey 1000, was installed without incident and has operated successfully for nearly two decades.


6 mile road off Hywy 17
The plan is to have wind turbines coming down this road
← House

THE MAIL

THE SAIGON SPY

Thomas A. Bass's profile of Pham Xuan An, the *Time* journalist who also spied for North Vietnam, includes an interview with Frank McCulloch, An's boss at *Time's* Saigon bureau ("The Spy Who Loved Us," May 23rd). Bass writes, "McCulloch remembers An with tremendous fondness and respect, and he says it was a 'great pleasure,' in 1990, to organize a subscription fund, which raised thirty-two thousand dollars, to send An's eldest son . . . to journalism school at the University of North Carolina. The list of subscribers to the fund reads like a Who's Who of Vietnam War reporters." It's easy to imagine the reaction this provokes among those of us who served in Vietnam and lost comrades there, friends whose families often faced serious financial difficulties after their deaths. Anyone who wonders why active-duty military personnel and veterans distrust the mainstream media need only read those two sentences.

David Clayton Carrad
Augusta, Ga.

I was a correspondent for *Time* in Vietnam, and I knew Pham Xuan An for nearly ten years. While spying for the North Vietnamese, An transformed *Time's* correspondents into an inadvertent worldwide network of spies for Hanoi. *Time* had high-level sources who often provided classified information on the condition that it would be kept secret and used only as background. The content of these confidential briefings was circulated internally in the weekly "*Time* memo," which was considered so sensitive that copies were numbered and returned after a reading by the editors. The memo contained much useless gossip, but also solid-gold insider reports from the White House, the State Department, and the Pentagon. The memo was also circulated to *Time* bureaus around the world, which were supposed to take equal precautions; An, as a *Time* reporter, had access to it. I often saw him taking notes from the Saigon bureau chief's confidential reports. These would have included briefings by Generals William Westmoreland and Creighton Abrams and Ambassadors Henry Cabot Lodge and Ellsworth Bunker, which often covered operations and strategy scheduled for weeks in the future. Then An would suddenly disappear without a word, presumably to brief his comrades in the tunnels of Cu Chi. I have always questioned the American journalists who insist on romanticizing An. It is one thing to have been against the Vietnam War—many of us were—but quite another to express unconditional admiration for a man who spent a large part of his life pretending to be a journalist while helping to kill Americans.

Zalin Grant
Paris, France

THE MUMMY RETURNS

I was struck by the photo accompanying Kevin Krajick's article on the paleopathologist and mummy expert Arthur Aufderheide, of a crouching Peruvian mummy, now in a museum in Quito, Ecuador ("The Mummy Doctor," May 16th). When, in the eighteen-eighties, a similar mummy, also in a fetal position, was exhibited at the Trocadero in Paris, it had a powerful influence on several modern artists, including Paul Gauguin. In Gauguin's late masterpiece "Where Do We Come From? What Are We? Where Are We Going?," the figure on the far left was directly inspired by his encounter with the mummy, which came to represent the theme of vanitas and morbidity in his works.

Laura Morowitz
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Wagner College
Staten Island, N.Y.

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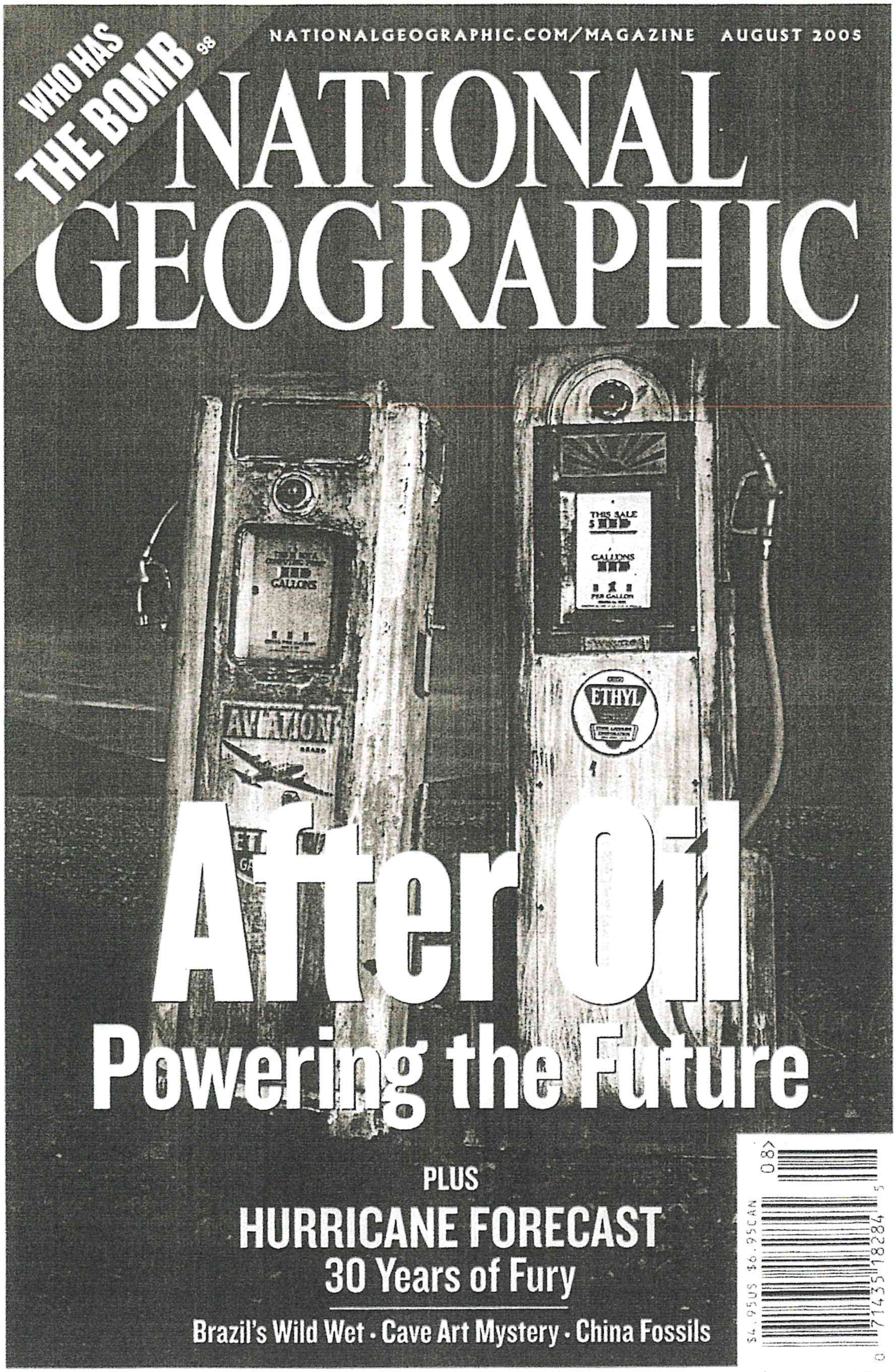
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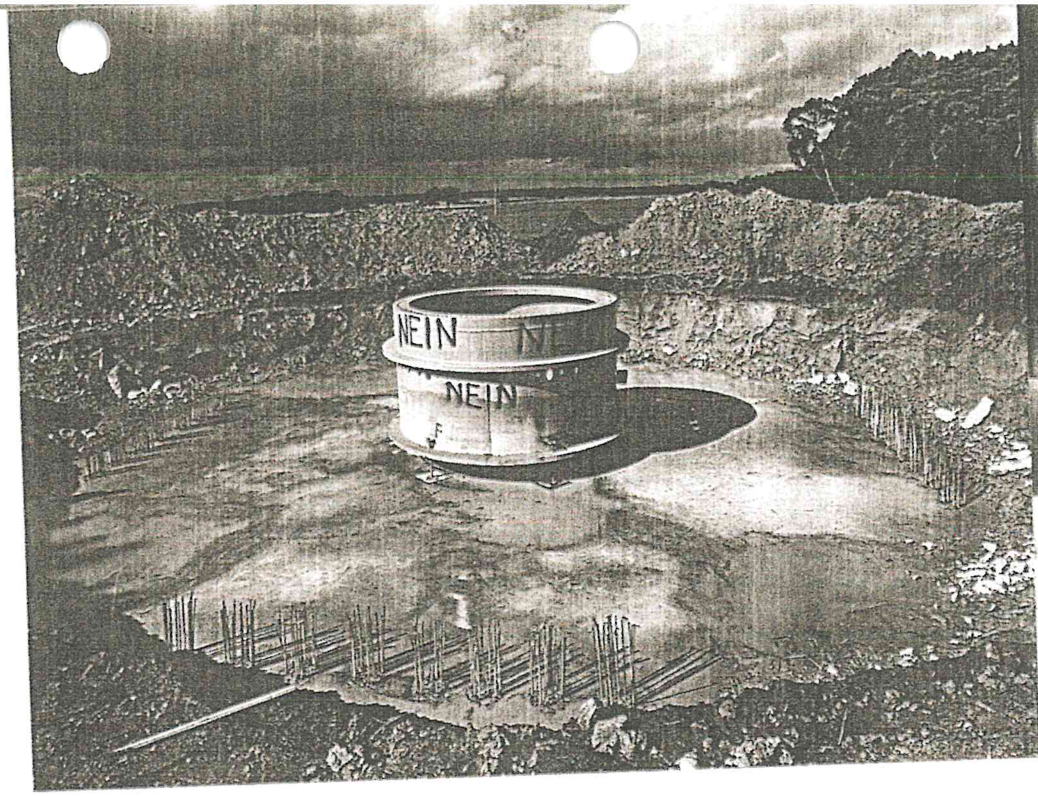
This is a good article on wind energy, a positive article.
I only copied a few pages to show you
how huge these turbines will be.
Please refer to page 6 of Power Point. Total height could be 492ft.

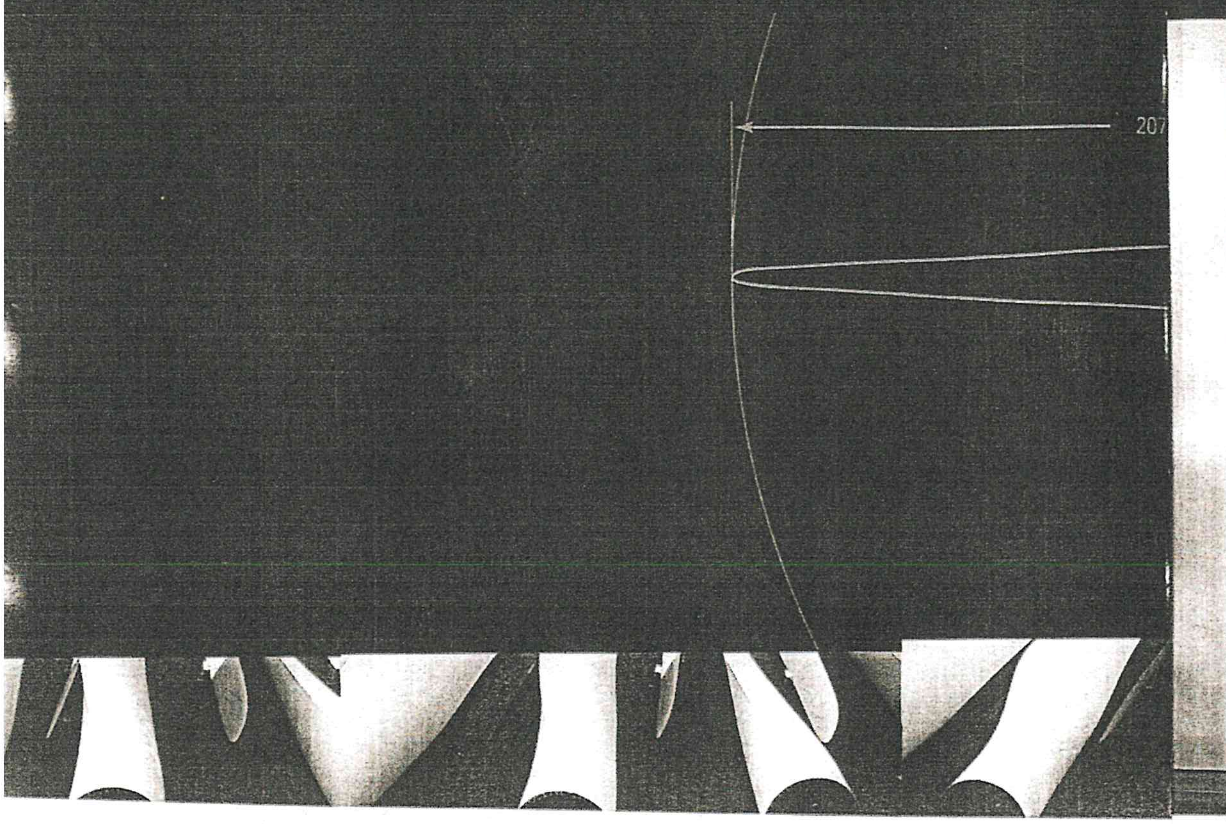


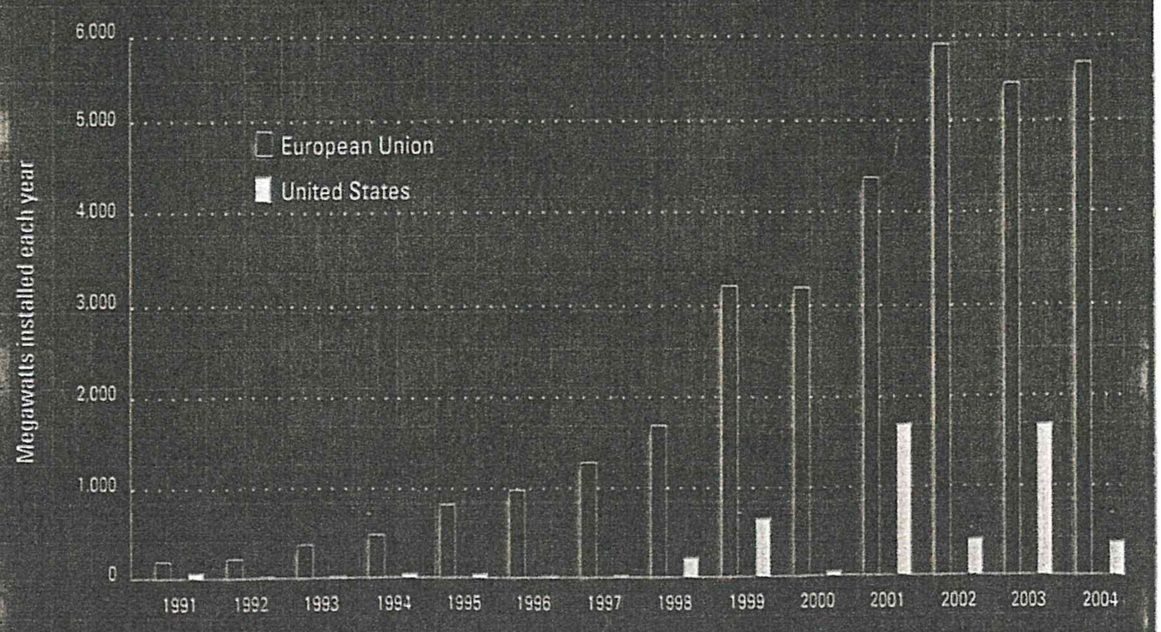
WIND RESISTANCE

While popular for the green energy they provide, turbines can also generate powerful protests. They take up large swaths of land, and some critics say they're noisy, unsightly, and a threat to birds and bats. Upset about a new installation, residents of Drenkow, Germany, display anti-turbine posters (below); nearby, the foundation for a new turbine bears the spray-painted word "no," in German (above). Such sentiments sometimes shove wind farms offshore, but even sea-based wind power isn't always welcome. A proposed wind farm off Cape Cod, Massachusetts, met fierce opposition from residents who feared it would spoil the vistas.

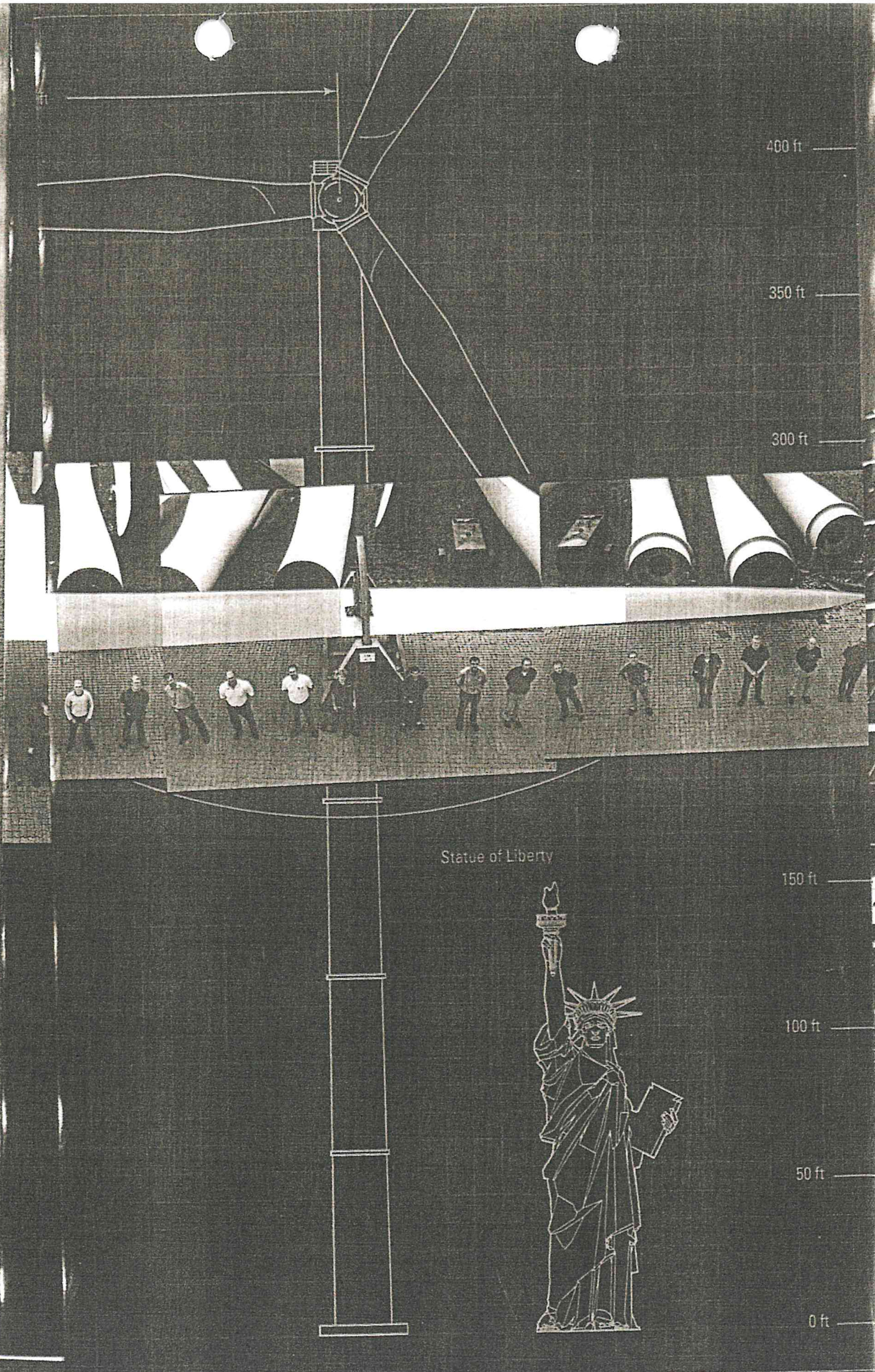
EUROPE'S AMBITIONS

BUILDING THE WORLD'S BIGGEST WIND TURBINE





ART BY CHARLES FLOYD, NGM ART. SOURCES: EUROPEAN WIND ENERGY ASSOCIATION AND AMERICAN WIND ENERGY ASSOCIATION


400 ft
350 ft
300 ft
Statue of Liberty
150 ft
100 ft
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