

Wind energy carries risk to environment, study finds

BY ANNE ADAMS • STAFF WRITER

MONTEREY — In what has been called the most in-depth study of wind energy in the Mid-Atlantic Highlands to date, a national committee of scientists and experts has concluded the issue of commercial wind generation is “surprisingly controversial.” But that comes as no surprise at all to residents here who have for nearly five years been debating the merits of industrial wind power while Highland New Wind Development LLC struggles to get approval for Virginia’s first such facility.

The study was conducted by the National Research Council, under the umbrella of the National Academies of Science, and released late last week. In general, the NRC found that information about the effects of commercial wind plants is woefully inadequate.

“At first glance, obtaining electricity from a free source of energy — the wind — seems to be an optimum contribution to the nation’s goal of energy independence and to solving the problem of climate warming due to greenhouse gas emissions,” it states. “As with many first glances, however, a deeper inspection results in a more complicated story. How wind turbines are viewed depends to some degree on the environment and people’s predilections, but not everyone considers them beautiful. Building wind-energy installations with large numbers of turbines can disrupt landscapes and habitats, and the rotating turbine blades sometimes kill birds and bats. Calculating how much wind energy currently displaces other, presumably less-desirable, energy sources is complicated, and predicting future displacements is surrounded by uncertainties.”

The industry is still relatively new, but thanks to federal subsidies and tax breaks, it has grown exponentially in the last few years. Regulating and planning projects in the U.S., however, is “relatively immature,” the study says.

“At the national scale, regulation is minimal, unless the project receives federal funding, and the regulations are generic for construction and management projects or are promulgated as guidelines,” the committee concluded. “Regulation at the state and local level is variable among jurisdictions, some with

well-developed policies and others with little or no framework, relying on local zoning ordinances. There are virtually no policy or regulatory frameworks at the multi-state regional scale, although of course the impacts and benefits of wind-energy installations are not constrained by political boundaries.

“This is the complex scientific and policy environment in which the committee worked to address its responsibility to study the environmental impacts of wind energy, including the adverse and beneficial effects.”

The group specifically studied impacts on landscapes, viewsheds, wildlife, habitats, water resources, air pollution, greenhouse gases, and materials-acquisition costs, among others.

It focused on the Mid-Atlantic Highlands — the mountains of Pennsylvania, Virginia, Maryland, and West Virginia.

“Using existing information, the committee was able to develop a framework for evaluating those effects; we hope this framework can inform future siting decisions of wind-energy projects. Often, there is insufficient information to provide certainty for these decisions, and thus in the process of its work the committee identified major research needed to improve the assessment of impacts and inform the siting and operational decisions of wind-energy projects,” the study says.

“The committee broadly defined ‘environmental’ impacts to include traditional environmental measures such as species, habitats, and air and water quality, but attention was also devoted to aesthetic, cultural, recreational, social, and economic impacts.”

The group looked, too, at the benefits of wind energy, and concluded those depend on “the degree to which the adverse effects of other energy sources can be reduced by using wind energy instead of the other sources.”

Not surprisingly, the committee said assessing the benefits of wind energy is complicated. “The generation of electricity by wind energy can itself have adverse effects, and projecting the amount of wind-generated electricity available in the future is quite uncertain,” the study said. “In addition, the amount of potential displacement of other energy sources depends on characteristics of the energy market, operation of the transmission grid, capacity factor of the wind-energy generators as well as that of other

types of electricity generators, and regulatory policies and practices affecting the production of greenhouse gases. Even if the amount of energy that wind energy displaces is small, it is clear that the nation will depend on multiple energy sources for the foreseeable future and reduction of environmental impacts will thereby require multiple approaches.”

The study explained the group expected to find “measurable environmental impacts” and that there would not be enough information to draw definitive conclusions.

“On the other hand,” the study said, “the lack of any truly coordinated planning, policy, and regulatory framework at all jurisdictional levels loomed larger than expected throughout our deliberations. Although some predictions about future adverse environmental effects of wind-energy use can be made, the committee recognized gaps in our knowledge and recommended specific monitoring studies that will enable more rigorous siting and operational decisions in the future.”

Ultimately, the group hopes to offer some guidance for getting to the assessments still needed. “We hope that the results of these deliberations and the evaluations and observations in this report will significantly improve the nation’s ability to plan, regulate, and assess the impacts of wind-energy development,” the report states.

Issues and recommendations

The more than 250-page report outlines several issues, the committee’s conclusions, and its recommendations for the industry. The following are excerpts on some of those topics.

■ **Regulation** — “The United States is in the early stages of learning how to plan for and regulate wind-energy facilities. Federal regulation of wind-energy facilities is minimal if the facility does not ... receive federal funding or require a federal permit, which is the case for most energy development in the United States. The Federal Energy Regulatory Commission regulates the interstate transmission of electricity, oil, and natural gas, but it does not regulate the construction of individual electricity-generation, transmission, or distri-

bution facilities. Apart from Federal Aviation Administration guidelines, federal and state environmental laws protecting birds and bats are the main legal constraints on wind-energy facilities not on federal lands or without a federal nexus.

“In evaluating current regulatory review processes, the committee was struck by the minimal guidance offered to developers, regulators or the public about (1) the quantity and kinds of information to be provided for review; (2) the degrees of adverse or beneficial effects of proposed wind developments to consider critical for approving or disallowing a proposed project; and (3) the competing costs and benefits of a proposed project to weigh, and how to weigh them, with regard to that single proposal or in comparison with likely alternatives if that project is not built. Such guidance, and technical assistance with gathering and interpreting information needed for decision making, would be enormously useful. This guidance and technical assistance cast at the appropriate jurisdictional level could be developed by state and local governments working with groups composed of wind-energy developers and nongovernmental organizations representing all views of wind energy, in addition to other government agencies.”

■ **Offsetting emissions** — “Wind-powered generators of electricity share some kinds of adverse environmental impacts with other types of electricity generators (for example, some clearing of vegetation is required to construct either a wind-energy or a coal-fired power plant and its access roads and transmission lines). Therefore, calculating the extent to which wind energy displaces other sources of electricity generation does not provide clear information on how much, or even whether, those other environmental impacts will be reduced. This report does, however, provide a guide to the methods and information needed to conduct a more comprehensive analysis.

“Projections for future wind-energy development, and hence projections for future wind-energy contributions to reduction of air-pollutant emissions in the United States, are highly uncertain. Recent model projections by the U.S. Department of Energy for U.S. onshore installed wind-energy capacity in the next 15 years range from 19 to 72 gigawatts GW, or 2 to 7 percent of projected U.S. onshore installed electricity-generation capacity. In the same period, wind-energy development is projected to account for 3.5 percent to 19 percent of the *increase* in total electricity-generation capacity. If the average wind-turbine size is assumed to be 2 MW (larger than most current turbines), 9,500 to 36,000 wind turbines would be needed to achieve that pro-

jected capacity.

“Because the wind blows intermittently, wind turbines often produce less electricity than their rated maximum output. On average in the mid-Atlantic region, the capacity factor of turbines — the fraction of their rated maximum output that they produce on average — is about 30 percent for current technology, and is forecast to improve to nearly 37 percent by the year 2020. Those are the fractions the committee used in estimating how much wind energy would displace other sources. Other factors, such as how wind energy is integrated into the electrical grid and how quickly other energy sources can be turned on and off, also affect the degree to which wind displaces other energy sources and their emissions. Those other factors probably further reduce the 30 percent (or projected 37 percent) figure, but the reduction probably is small, at least for the projected amount of onshore wind development in the United States.

“The net result in the mid-Atlantic region is unclear. Because the amount of atmospheric pollutants emitted varies from one energy source to another, assumptions must be made about which energy source will be displaced by wind. However, even assuming that all the electricity generation displaced by wind in the mid-Atlantic region is from coal-fired power plants, as one analysis has done, the results do not vary dramatically from those based on the assumption that the average mix of electricity sources in the region is displaced.

“In addition to CO₂, coal-fired power plants also are important sources of SO₂ and NO_x emissions. Those two pollutants cause acid deposition and contribute to concentrations of airborne particulate matter. NO_x is an important precursor to ozone pollution in the lower atmosphere. However, because current and upcoming regulatory controls on emissions of NO_x and SO₂ from electricity generation in the eastern United States involve total caps on emissions, the committee concludes that development of wind-powered electricity generation using current technology probably will not result in a significant reduction in total emission of these pollutants from the electricity sector in the mid-Atlantic region.

“Using the future projections of installed U.S. energy capacity by the DOE ... the committee estimates that wind-energy development probably will contribute to offsets of approximately 4.5 percent in U.S. emissions of CO₂ from electricity generation by other electricity-generation sources by the year 2020. In 2005, electricity generation produced 39 percent of all CO₂ emissions in the United States.

“Wind energy will contribute proportion-

ately less to electricity generation in the mid-Atlantic region than in the United States as a whole, because a smaller portion of the region has high-quality wind resources than the portion of high-quality wind resources in the United States as a whole.

“If the future were to bring more aggressive renewable-energy-development policies, potential increased energy conservation, and improved technology of wind-energy generation and transmission of electricity, the contribution of wind energy to total electricity production would be greater. This would affect our analysis, including projections for development and associated effects (for example, energy supply, air pollution, and development footprint). On the other hand, if technological advances serve to reduce the emissions and other negative effects of other sources of electricity generation or if fossil-fuel prices fall, the committee’s findings might overestimate wind’s contribution to electricity production and air-pollution offsets.”

■ **Ecological impacts** — “Wind turbines cause fatalities of birds and bats through collision, most likely with the turbine blades. Species differ in their vulnerability to collision, in the likelihood that fatalities will have large-scale cumulative impacts on biotic communities, and in the extent to which their fatalities are discovered. Probabilities of fatality are a function of both abundance and behavioral characteristics of species. Among bird species, nocturnal, migrating passerines are the most common fatalities at wind-energy facilities, probably due to their abundance, although numerous raptor fatalities have been reported, and raptors may be most vulnerable, particularly in the western United States.

“However, the number of fatalities must be considered in relation to the characteristics of the species. For example, fatalities probably have greater detrimental effects on bat and raptor populations than on most bird populations because of the characteristically long life spans and low reproductive rates of bats and raptors and because of the relatively low abundance of raptors.

“Determining the effect of turbine size on avian risk will require more data from direct comparison of fatalities from a range of turbine types.

“The location of turbines within a region or landscape influences fatalities. Turbines placed on ridges, as many are in the Mid-Atlantic Highlands, appear to have a higher probability of causing bat fatalities than those at many other sites.

“The overall importance of turbine-related deaths for bird populations is unclear. Collisions with wind turbines represent one element

of the cumulative anthropogenic impacts on these populations; other impacts include collisions with other structures and vehicles, and other sources of mortality ... those other sources kill many more birds than wind turbines, even though precise data on total bird deaths caused by most of these anthropogenic sources are sparser and less reliable than one would wish.

“The construction and maintenance of wind-energy facilities also alter ecosystem structure through vegetation clearing, soil disruption and potential for erosion, and noise. Alteration of vegetation, including forest clearing, represents perhaps the most significant potential change through fragmentation and loss of habitat for some species. Such alteration of vegetation is particularly important for forest-dependent species in the Mid-Atlantic Highlands. Changes in forest structure and the creation of openings alter microclimate and increase the amount of forest edge. Plants and animals throughout an ecosystem respond differently to these changes. There might also be important interactions between habitat alteration and the risk of fatalities, such as bat foraging behavior near turbines.

“Although the analysis of cumulative effects of anthropogenic energy sources other than wind was beyond the scope of the committee, a better analysis of the cumulative effects of various anthropogenic energy sources, including wind turbines, on bird and bat fatalities is needed, especially given projections of substantial increases in the numbers of wind turbines in coming decades.

“In the Mid-Atlantic Highlands, preliminary information indicates that more bats are killed than was expected based on experience with bats in other regions. Not enough information is available to form a reliable judgment on whether the number of bats being killed will have overall effects on populations, but given a general region-wide decline in the populations of several species of bats in the eastern United States, the possibility of population effects, especially with increased numbers of turbines, is significant.

“Standardized studies should be conducted before siting and construction and after construction of wind-energy facilities to evaluate the potential and realized ecological impacts of wind development. Pre-siting studies should evaluate the potential for impacts to occur and the possible cumulative impacts in the context of other sites being developed or proposed.”

■ **Impacts on humans** — “The human impacts considered by the committee include aesthetic impacts; impacts on cultural resources, such as historic, sacred, archeologi-

cal, and recreation sites; impacts on human health and well-being, specifically from noise and from shadow flicker; economic and fiscal impacts; and the potential for electromagnetic interference with television and radio broadcasting, cellular phones, and radar. This is not an exhaustive list of all possible human impacts from wind-energy projects. For example, the committee did not address potentially significant social impacts on community cohesion, such as cases where proposed wind-energy facilities might cause rifts between those who favor them and those who oppose them. Psychological impacts — positive as well as negative — that can arise in confronting a controversial project also were not addressed.

“There has been relatively little dispassionate analysis of the human impacts of wind-energy projects in the United States. In the absence of extensive data, this report focuses mainly on appropriate methods for analysis and assessment and on recommended practices in the face of uncertainty.

“There are systematic and well-established methods for assessing and evaluating human impacts; they allow better-informed and more-enlightened decision making.

“Although aesthetic concerns often are the most-vocalized concerns about proposed wind-energy projects, few decision processes adequately address them. Although methods for assessing aesthetic impacts need to be adapted to the particular characteristics of wind-energy projects, such as their visibility, the basic principles of systematically understanding the relationship of a project to surrounding scenic resources apply and can be used to inform siting and regulatory decisions.

“Because relatively little research has been done on the human impacts of wind-energy projects, when wind-energy projects are undertaken, routine documentation should be made of processes that allow for local interactions concerning the impacts that arise during the lifetime of the project, from proposal through decommissioning, as well as processes for addressing the impacts themselves. Such documentation will facilitate future research and therefore improve future siting decisions.

“Human impacts should be considered within the context of the environmental impacts ... and the broader contextual analysis of wind energy — including its electricity-production benefits and limitations.”

■ **Analyzing adverse and beneficial impacts in context** — “An ideal framework that addressed all effects of wind energy across a variety of spatial and temporal scales would require more information than the committee could gather, given its time and resources, and

probably more information than currently exists. In addition, energy development in general, and wind-energy development in particular, are not evaluated and regulated in a comprehensive and comparative way in the United States, and planning for new energy resources also is not conducted in this manner. Instead, planning, regulation, and review usually are done on a project-by-project basis and on local or regional, but not national, scales. In addition, there are few opportunities for full life-cycle analyses or consideration of cumulative effects.

“A country as large and as geographically diverse as the United States and as wedded to political plurality and private enterprise is unlikely to plan for wind energy at a national scale in the same way as some European countries are doing. Nevertheless, national-level energy policies (implemented through such mechanisms as incentives, subsidies, research agendas, and federal regulations and guidelines) to enhance the benefits of wind energy while minimizing the negative impacts would help in planning and regulating wind-energy development at smaller scales. Uncertainty about what policy tools will be in force hampers proactive planning for wind-energy development.

“Guidance on planning for wind-energy development, including information requirements and procedures for reviewing wind-energy proposals ... should be developed. In addition, technical assistance with gathering and interpreting information needed for decision making should be provided. This guidance and technical assistance, conducted at appropriate jurisdictional levels, could be developed by working groups composed of wind-energy developers; nongovernmental organizations with diverse views of wind-energy development; and local, state, and federal government agencies.

“Regulatory reviews of individual wind-energy projects should be preceded by coordinated, anticipatory planning whenever possible. Such planning for wind-energy development, coordinated with regulatory review of wind-energy proposals, would benefit developers, regulators, and the public because it would prompt developers to focus proposals on locations and site designs most likely to be successful. This planning could be implemented at scales ranging from state and regional levels to local levels. Anticipatory planning for wind-energy development also would help researchers to target their efforts where they will be most informative for future wind-development decisions.

“Choosing the level of regulatory authority for reviewing wind-energy proposals carries corresponding implications for how the

following issues are addressed:

(1) cumulative effects of wind-energy development;

(2) balancing negative and positive environmental and socioeconomic impacts of wind energy; and

(3) incorporating public opinions into the review process.

“In choosing the levels of regulatory review of wind-energy projects, agencies should review the implication of those choices for all three issues listed above. Decisions about the level of regulatory review should include procedures for ameliorating the disadvantages of a particular choice (for example, enhancing opportunities for local participation in state-level reviews).

“Well-specified, formal procedures for regulatory review enhance predictability, consistency, and accountability for all parties to wind-energy development. However, flexibility and informality also have advantages, such as matching the time and effort expended on review to the complexity and controversy associated with a particular proposal; tailoring decision criteria to the ecological and social contexts of a particular proposal; and fostering creative interactions among developers, regulators, and the public to find solutions to wind-energy dilemmas.

“When consideration is given to formalizing review procedures and specifying thresholds for decision criteria, this consideration should include attention to ways of retaining the advantages of more flexible procedures.

“Using an evaluation guide ... to organize regulatory review processes can help to achieve comprehensive and consistent regulation coordinated across jurisdictional levels and across types of effects.

“Regulatory agencies should adopt and routinely use an evaluation guide in their reviews of wind-energy projects. The guide should be available to developers and the public.

“The environmental benefits of wind-energy development, mainly reductions in atmospheric pollutants, are enjoyed at wide spatial scales, while the environmental costs, mainly aesthetic impacts and ecological impacts, such as increased mortality of birds and bats, occur at much smaller spatial scales. There are similar, if less dramatic, disparities in the scales of realized economic and other societal benefits and costs. The disparities in scale, although not unique to wind-energy development, complicate the evaluation of trade-offs.

“Representatives of federal, state, and local governments should work with wind-energy developers, nongovernmental organizations, and other interest groups and experts to develop guidelines for addressing trade-offs

between benefits and costs of wind-energy generation of electricity that occur at widely different scales, including life-cycle effects.”

For further information on the study, see: www.nationalacademies.org.