To: CESA Members
From: Mark Sinclair
Date: May 4, 2007
Re: Summary of National Research Council Report on Environmental Impacts of Wind-Energy Projects

Two years ago, the National Research Council was asked by Congress to review the positive and negative environmental impacts of wind-energy development. On May 3rd, the Council issued a comprehensive report that proposes a framework for evaluating tradeoffs between the benefit of new wind-energy projects and risk of adverse environmental impacts before projects begin. The report urges federal and state agencies to take the environmental impacts of wind-energy more seriously as part of planning, locating, and regulating these facilities – largely because some bird and bat collisions with blades and turbines may begin to threaten local populations of some species with rapid expansion of wind facilities over the next 20 years. The report notes that bat populations in the Mid-Atlantic region may be particularly at risk.

The NRC's report is available for purchase through the Academies' website (http://www.nationalacademies.org/), and copies of the executive summary and the report in brief are free from the website.

- **Scope of Report:**

Congress mandated the National Research Council to establish an expert committee to carry out a scientific study of the environmental impacts of wind-energy projects, focusing on the Mid-Atlantic Highlands (MAH) as a case example. The study was to consider adverse and beneficial effects, including impacts on landscapes, viewsheds, wildlife, habitats, water resources, air pollution, greenhouse gases, materials-acquisition costs, and other impacts. The committee was charged to develop an analytical framework for evaluating those effects to inform siting decisions for wind-energy projects. The study also was to identify major areas of research and development needed to better understand the environmental impacts of wind-energy projects and to reduce or mitigate negative environmental effects.

Here are the major findings of the report:

1. Lack of Current Guidance for Reviewing Wind-Energy Proposals

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 have a federal nexus (that is, receive federal funding or require a federal permit), which is the case for most energy development in the United States. The FERC does not regulate the construction of individual electricity-generation, transmission, or distribution facilities. Apart from FAA

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.

Regulation of wind energy is evolving rapidly. 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 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.

2. Environmental Benefits of Wind Energy

The environmental benefits of wind energy accrue through its displacement of electricity generation that uses other energy sources, thereby displacing the adverse environmental effects of those generators. The committee's charge was to focus on the use of wind energy; it did to evaluate fully the effects of other energy sources. Thus, in assessing environmental benefits of wind-energy generation of electricity, the committee focused on the degree to which it displaces or renders unnecessary the electricity generated by other sources, and hence on the degree to which it displaces or reduces atmospheric emissions, which include greenhouse gases, mainly carbon dioxide (CO2); oxides of nitrogen (NOx); sulfur dioxide (SO2); and particulate matter.

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 DOE for U.S. onshore installed wind-energy capacity in the next 15 years range from 19 to 72 gigawatts (GW), or 2 to 7% of projected U.S. onshore installed electricity-generation capacity. In the same period, wind-energy development is projected to account for 3.5% to 19% 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 projected capacity.

Conclusions

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

- Wind energy will contribute proportionately 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. That potential is estimated to be less than 4.5%, and the degree to which its beneficial effects would be realized in the MAH is uncertain.

3. 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. Among bats, migratory tree roosting species appear to be the most susceptible. 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.

The type of turbines may influence bird and bat fatalities. Newer, larger turbines appear to cause fewer raptor fatalities than smaller turbines common at the older wind-energy facilities in California, although this observation needs further comparative study to better account for such factors as site-specific differences in raptor abundance and behavior. However, the data are inadequate to assess relative risk to passerines and other small birds. It is possible that as turbines become larger and reach higher, the risk to the more abundant bats and nocturnally migrating passerines at these altitudes will increase. 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 MAH, 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. Any assessment of the importance of a source of bird mortality requires information and understanding about the species affected and the likely consequences for local populations of those species.

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 MAH. 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.

Conclusions

- 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 MAH, 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.

- At the current level of wind-energy development (approximately 11,600 MW of installed capacity in the United States at the end of 2006, including the older California turbines), the committee sees no evidence that fatalities caused by wind turbines result in measurable demographic changes to bird populations in the United States, with the possible exception of raptor fatalities in the Altamont Pass area, although data are lacking for a substantial portion of the operating facilities.

- There is insufficient information available at present to form a reliable judgment on the likely effect of all the proposed or planned wind-energy installations in the mid-Atlantic region on bird populations. To make such a judgment, information would be needed on the future number, size, and placement of those turbines; more information on bird populations, movements, and susceptibility to collisions with turbines would be needed as well. Lack of replication of studies among facilities and across years makes it impossible to evaluate natural variability.

Recommendation

- 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. Likely impacts could be evaluated relative to other potentially developable sites or from an absolute perspective. In addition, the studies should evaluate a selected site to determine whether alternative facility designs would reduce potential environmental impacts. Post-construction studies should focus on evaluating impacts,

actual versus predicted risk, causal mechanisms of impact, and potential mitigation measures to reduce risk and reclamation of disturbed sites. Additional research is needed to help assess the immediate and long-term impacts of wind-energy facilities on threatened, endangered, and other species at risk. Detailed recommendations on studies needs are provided in Ch. 3.

4. Impacts on Humans

The human impacts considered by the committee include aesthetic impacts; impacts on cultural resources, such as historic, sacred, archeological, 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. 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, the report focuses mainly on appropriate methods for analysis and assessment and on recommended practices in the face of uncertainty, including guides to best practices and descriptions of information needs.

Conclusions

- 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 (described in Chapter 4 and Appendix D) of systematically understanding the relationship of a project to surrounding scenic resources apply and can be used to inform siting and regulatory decisions.

Recommendations

- 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 not be considered in isolation but within the context of the environmental impacts and the broader contextual analysis of wind energy—including its electricity-production benefits and limitations. Questions and issues concerning human

impacts should be covered in assessments and regulatory reviews of wind-energy projects.

5. Analyzing Adverse and Beneficial Impacts in Context

An ideal framework that addresses 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.

There also are no agreed-on standards for weighting of positive and negative effects of a proposed energy project and for comparing those effects to those of other possible or existing projects. Indeed, the appropriate standards and methods of conducting such comparisons are not obvious, and it is not obvious what the appropriate space and times scales for the comparisons should be. Therefore, a full comparative analysis was not attempted.

The committee stopped short of providing a full analytic framework and instead offers an evaluation guide to aid coordination of regulatory review across levels of government and across spatial scales and to help to ensure that regulatory reviews are comprehensive in addressing the many facets of the human and nonhuman environment that can be affected by wind-energy development ----

Recommended Guide for Evaluating Wind-Energy Projects

Elements to consider in policy, planning, and public relations

- *Are the relevant energy policies and planning processes clearly defined at all jurisdictional levels, and are they coordinated and aligned among federal, state and local levels? Are national-level energy policies available and being used: Are well-reasoned planning documents available to make regulatory-review actions predictable and defensible?*

- *Have mechanisms been established to provide necessary information to interested and affected parties, and to seek meaningful input from them as wind-energy projects are planned and implemented? Are developers required to provide early notification of their intent to develop wind energy?*

- *Are procedures—including policies and regulations—in place for evaluating the impacts of wind-energy projects that cross jurisdictional boundaries?*

- *Is guidance available to developers, regulators, and the public about what kinds of information are needed for review, what degrees of adverse and beneficial effects of proposed wind-energy developments should be considered critical in evaluating a proposed project, and how competing costs and benefits of a proposed project should be weighed with regard to that proposal only, or by comparison with likely alternatives?*

- *Are regional planning documents available that provide guidance on the quality of wind resources, capacity of transmission options, potential markets, major areas of concern, and tradeoffs that should be considered?*

Legal and Regulatory Considerations

- *Are wind-energy guidelines and regulations issued by different federal agencies compatible, are those guidelines and regulations aligned with other federal regulating rules and regulations, and do the guidelines and regulations follow acceptable scientific principles when establishing data requirements?*

- *Does the review process include steps that explicitly address the cumulative impacts of wind-energy projects over space and time; that is, by reviewing each new project in the context of other existing and planned projects in the region?*

Evaluation of Impacts

- *Are the biological, aesthetic, cultural, and socioeconomic attributes of the region sufficiently well known to allow an accurate assessment of the environmental impacts of the wind-energy project, and to distinguish among the potential sites considered during the site selection process? Are there species, habitats, recreational areas, or cultural sites of special interest or concern that will be affected by the project? Are there key gaps in the needed information that should be addressed with further research before a project is approved or to guide the operation of an approved project?*

Environmental Impacts

- *What environmental mitigation measures will be taken and how will their effectiveness be measured? Are there any legal requirements for such measures (e.g., habitat conservation plans)? Are any listed species at risk from the proposed facility?*

- *How and by whom will the environmental impacts be evaluated once the project is in operation? If these evaluations indicate needed changes in the operation of the facility, how will such a decision be made and how will their implementation be assured?*

- *What pre-siting studies for site selection and pre-construction studies for impact assessment and mitigation planning are required?*

- *What post-construction studies, with appropriate controls, are required to evaluate impacts, modify mitigation if needed, and improve future planning?*

Impacts on Human Health and Well-Being

- *Have pre-construction noise surveys been conducted to determine the background noise levels? Will technical assessments of the operational noise levels be conducted? Is there an established process to resolve complaints from the operation of the turbines?*

- *Is there a process in place to address complaints of shadow flicker and does the operator use the best software programs to minimize any flicker?*

Aesthetic Impacts

- *Has the project planning involved professional assessment of potential visual impacts, using established techniques such as those recommended by the U.S. Forest Service or U.S. Bureau of Land Management?*

- *How have the public and the locally affected inhabitants been involved in evaluating the potential aesthetic and visual impacts?*

Cultural Impacts

- *Has there been expert consideration of the possible impacts of the project on recreational opportunities and on historical, sacred, and archeological sites?*

Economic and Fiscal Impacts

- *Have the direct economic impacts of the project been accurately evaluated, including the types and pay scales of the jobs produced during the construction and operational phases, the taxes that will be produced, and costs to the public?*

- *Has there been a careful explication of the indirect economic costs and benefits, including opportunity costs and the distribution of monetary and non-monetary benefits and costs?*

- *Are the guarantees and mitigation measures designed to fit the project and address the interests of the community members and the local jurisdictions?*

Electromagnetic Interference

- *Has the developer assessed the possibility of radio, television, and radar interference?*

Cumulative Effects

- *How will cumulative effects be assessed, and what will be included in that assessment (i.e., the effects only of other wind-energy installations, or of all other electricity*

generators, or of all other anthropogenic impacts on the area)? Have the spatial and temporal scales of the cumulative-effects assessment been specified?

6. Framework for Reviewing Wind-Energy Proposals

Conclusion

- 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.

- Because wind energy is new to many state and local governments, the quality of processes for permitting wind-energy developments is uneven in many respects.

Recommendation

- Guidance on planning for wind-energy development, including information requirements and procedures for reviewing wind-energy proposals (see matrix above) 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.

Conclusion

- There is little anticipatory planning for wind-energy projects, and even if it occurred, it is not clear whether mechanisms exist that could incorporate such planning in regulatory decisions.

Recommendation

- 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.

Conclusion

- 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.

Recommendation

- 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).

Conclusion

- 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.

Recommendation

- 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.

Conclusion

- Using an evaluation guide such as the one recommended above to organize regulatory review processes can help to achieve comprehensive and consistent regulation coordinated across jurisdictional levels and across types of effects.

Recommendation

- 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.

Conclusion

- 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 tradeoffs.

Recommendation

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