

***Spatially explicit ecosystem-based management of wind farm development to minimize use conflicts and maximize energy production and ecological synergies: A North Carolina (USA) example for Pamlico and Albemarle Sounds and the coastal ocean***

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Extended Abstract

This presentation presents a model application of marine ecosystem-based management applied to spatially explicit planning for wind farm development in the sounds and off the coast of North Carolina. Planning includes assessment of spatial distributions of available wind power, ecological risks and synergies, use conflicts affecting site selection, foundation systems and their compatibility with sound and ocean bottom geology and associated geologic dynamics, electric transmission infrastructure, utility statutory and regulatory barriers, the legal context, carbon reduction potential, and economics. Key findings in each of these areas as well as the overall conclusions are discussed below.

***Wind Power:*** Estimates of wind power potential in coastal North Carolina from AWS Truewind were evaluated using existing wind observations and atmospheric models including publicly-available weather data, NC State Observation of Wind (SOW) meteorological towers, and privately collected over-water wind data from the Sounds. In addition, limited deployments of a Sound Direction and Range (SODAR) system owned by UNC Chapel Hill collected vertical wind profiles. There is a rapid increase in wind energy potential as one moves from land over water and offshore. The AWS Truewind product appears to over-estimate wind speeds over land where wind speeds are less than 6 m/s. At the coastline and over water AWS Truewind is more consistent with the observations but may over-estimate winds in the vicinity of Cape Fear and in northeast NC. Wind power class abruptly transitions from 1-2 over land to 4 or greater over water. Wind power class 6 is common offshore and may reach class 7 in the vicinity of Cape Hatteras. Within the Sounds, wind power class 5 is likely in eastern Pamlico Sound and less elsewhere. To examine utility-scale wind generation potential wind speeds were translated to power using a power curve typical of 3-3.6 MW wind turbines and the result expressed as a capacity factor. Estimated capacity factors are above 30% for eastern Pamlico Sound and for most of the offshore region. Capacity factors above 40% are likely on the continental shelf between central Onslow Bay and The Point in water depths of 30 m and greater and over portions of Cape Lookout and Diamond Shoals.

***Ecological Risks and Synergies:*** Birds and bats represent the organisms at greatest risk to wind turbines over water, based upon distribution patterns, behavioral responses, and observations made on wind mill impacts on land. Summering and wintering waterbirds are ubiquitous in the sounds, and the nearshore coastal ocean out 2 miles is heavily used by fish-eating waterbirds and transited by migratory songbirds and shorebirds of concern. Marine mammals, sea turtles, fish, and bottom-dwelling invertebrates could also be

harmful by noise and other factors, especially during the construction phase. Depending upon location, positive environmental synergies include establishment of oyster reefs in saline sounds, creation of additional rocky hard-bottom reefs in the coastal ocean, facilitating offshore mariculture, and enhancing local upwelling - thereby mixing oxygen into seasonally oxygen depleted sound water and increasing productivity in the coastal ocean. Several large coastal areas offshore in federal waters were identified as being of lower risk to birds, bats, and marine life.

***Conflicts Affecting Site Selection:*** Military uses for low-altitude training flights, radar communications, and amphibious landings, as well as traditional navigation corridors like inlets and marked channels, ocean shipping lanes, and fishing grounds, render large areas of the Pamlico Sound and some regions of the coastal ocean incompatible with the establishment of wind farms. Heavily fished areas where bottom dredging or trawling is practiced would pose dangers to buried transmission cables. Existing oyster reef sanctuaries and seagrass beds in Pamlico Sound, plus live-bottom reef habitats and shipwrecks offshore, including the Monitor National Marine Sanctuary, are incompatible with the installation of wind turbines. Because of exceptional use by wildlife and consequent valuable human uses, inlets, cape shoals, The Point region near Cape Hatteras, and the Gulf Stream represent inappropriate locations for wind farms. Barges needed for turbine installation require water depths at least 4 m in depth. Because the National Seashores comprise such a large fraction of the coast of North Carolina, concerns over unacceptable visual impacts arise, suggesting need for site-specific reviews of plans by the National Park Service especially near lighthouses and historic villages.

***Foundation Systems:*** Foundation systems include monopiles and gravity based systems. Monopiles are suited to unconsolidated sediments. The monopile foundations for 3.0-3.6 MW turbines are driven to a depth of 30-35 meters below the seafloor. Monopiles also can be used in softer partially consolidated sediments, but drilling may be required in localized situations. In soft substrates with numerous harder, rocky interbeds, a drive-drill-drive approach can be used throughout but increases the cost up to 100%. Gravity based structures are used where the seafloor consists of rock too hard for piled foundations. These foundations rely on mass, including ballast material, to withstand the axial and lateral forces and the overturning moment generated by the local environment and the turbine. Ballast material typically is rock aggregate but can be iron or concrete as well, all of which can become important live-bottom habitats. Transportation and installation of the foundations requires specially adapted vessels having a draft approaching 4.5 meters.

***Geologic Framework:*** The North Carolina coastal system has a complex geologic framework with major differences occurring between inshore and offshore segments as well as between the north and south continental shelf components. The offshore continental shelf area is subdivided into three regions for this study: south of Cape Lookout including Onslow and Long Bays, Raleigh Bay between Cape Lookout and Cape Hatteras, and Hatteras Bay north of Cape Hatteras. The inshore estuarine water bodies of northeastern North Carolina are analyzed separately. The different geologic framework produces dissimilar rock and sediment types, topography, land slopes, and

dynamic geologic processes. Onslow and Long Bays have broad, shallow shelves dominated by hard-bottoms. Raleigh and Hatteras Bays are narrower, slightly steeper, and dominated by unconsolidated sediments with substantial amounts of surficial relief. For each of these bays, geologic bottom maps differentiate areas with the best potential for wind turbines from those areas with little to no potential for foundation systems as well as transitional areas that may have future potential but require further study.

***Utility Transmission Infrastructure:*** The potential for integrating an offshore wind project was evaluated separately by electric utility service territory. In all cases, these assessments are high level, based on the providers' Open Access Transmission Tariffs, discussions with transmission planners, and the 2008 North Carolina Transmission Planning Collaborative report. The Dominion North Carolina Power transmission system on the northern coast is not designed to accommodate significant offshore wind without a system upgrade. Interconnection feasibility, without upgrade, is likely in the vicinity of 10 MW, suitable for a pilot project but not a commercial wind farm. The North Carolina Electric Membership Cooperatives do not own significant infrastructure. Progress Energy Carolinas' transmission could accommodate up to 250 MW of offshore wind energy generation at Morehead City or Wilmington without major upgrades. The economics are significantly impacted by the distance required to reach the transmission grid from the offshore wind location.

***Utility-Related Statutory and Regulatory Barriers:*** The major regulatory issue for public utilities is cost recovery. For an independent power producer, the major regulatory issues concern access to markets and the price paid for generation. There are few outright regulatory barriers but the regulatory incentives for wind energy are not as great as for other forms of alternative energy, resulting in solar energy being pursued more aggressively by the public utilities in spite of its greater cost. Three possibilities for increasing incentives for wind power development are (1) including the cost of externalities (CO<sub>2</sub> related costs) in the avoided cost calculation used for determining the baseline for cost recovery, (2) raising the cost caps applicable to meeting the North Carolina Renewable Energy Portfolio Standard, and (3) extending the federal Production Tax Credit beyond 2009. Actions to enhance prospects for independent power producers include ensuring the efficient access to markets begun by the Public Utility Regulatory Policies Act (PURPA) of 1978 continues, such as the development of standard contracts and the extension of the must-take provision to projects greater than 80 MW.

***Legal Framework, Issues, and Policy Concerns:*** Existing North Carolina law presents significant legal and regulatory barriers to permitting wind energy development in State coastal waters. Certain State regulations currently impede or prohibit wind energy projects in State Sounds, and there is uncertainty as to the jurisdictional authority over any permitting process. Furthermore, the federal government now has a regulatory framework in place to lease federal submerged lands on the Outer Continental Shelf (OCS) for renewable energy projects. Therefore, North Carolina needs to prepare itself in the event federal OCS lands are leased for wind energy development in a location that may impact its coast. In addition, there is a complex suite of federal laws that would apply to wind energy projects and federal permits that would need to be obtained. An

OCS leasing process has been promulgated by MMS; federal permits are required for wind energy projects and the federal laws apply; and, to the extent a project located on the OCS will affect North Carolina's interests, the State may protect those interests through the consistency provision of the federal Coastal Zone Management Act. The existing State-level statutory framework for the issuance of submerged lands leases has gaps in that framework as they relate to wind energy projects; and various regulatory issues may impede development of wind energy in State waters, which the State needs to address.

***Carbon Reduction:*** Electricity purchased from the grid is a blend of energy generated by coal, nuclear, hydroelectric, gas, oil, and renewable generators. Each kilowatt hour represents a blend of the generating capacity of the surrounding region, which differs markedly across regions of the US. The carbon reduction potential of a wind energy project depends on the fuel generation mix of the utility supplying electric power to the grid and the fuels in use at the time of day when the wind is most productive. It will vary over time with changes in the baseline emissions profile. For example, if coal-fired power plants are replaced with nuclear plants, the carbon reduction potential of wind energy is diminished. Two scenarios were used to estimate carbon reduction potential. The first, a small inshore farm with 30 3.6 MW turbines and a capacity factor of 35%, would generate about 330,000 megawatt hours of electricity per year and offset between 170,000 and 270,000 metric tons of carbon dioxide equivalents (MTCDE). Over a 20 year lifetime, this reduction would be the equivalent of taking 550,000 vehicles off the road or offsetting the combustion of 16,000 rail cars of coal. The second, a large offshore farm with 450 3.6 MW turbines with a 40% capacity factor, would generate about 5.7 million megawatt hours of electricity per year, offsetting between 3 and 5 million MTCDE at inception, and more than 50 million MTCDE over the project's lifetime, the equivalent of displacing 9 million cars or the yearly emissions from 11 coal-fired power plants.

***Economics:*** A preliminary economic screening analysis was performed on two sample project scenarios, one inshore with 30 turbines and 108 MW of installed capacity and one offshore with 450 turbines and 1,620 MW installed capacity. The inshore project is assumed to be developed owned, and operated as a merchant plant while the offshore project is owned and operated by an investor owned utility (IOU), resulting in different capital structures. The offshore project entails high capital costs and operations and maintenance expense, but offers a better capacity factor and scale. Levelized cost of generation (LCOG) is used as the measure of economic performance. LCOG is that constant price per MWh of generation in nominal dollars that results in the recovery of all project costs including after tax cost of equity. The pricing/delivery point is assumed to be the busbar, i.e. it excludes transmission and distribution costs beyond the point of interconnection. The offshore scenario offers slightly better economic performance with an estimated LCOG of \$101 per MWh versus \$106 per MWh for the inshore scenario. Within the uncertainty ranges considered, LCOG is particularly sensitive to capital cost and loss of favorable tax treatment. LCOG is also sensitive to capacity factor, operation and maintenance expense, and capital structure. It is noteworthy that the inshore project

offers a lower LCOG by about \$6 per MWh if the capital structure of the two scenarios is the same.

**Synthesis:** Each team described the opportunities and constraints for coastal wind energy development. Information from the individual groups was integrated into a geographic information system. In synthesizing the data, emphasis was placed on identifying severe constraints likely to preclude any wind energy development. Areas identified as no-build (e.g. too shallow, reserved for use by the military) and areas identified as having high ecological impact or low suitability for foundation construction were eliminated. We opted to equally weight each constraint and assume an equal degree of certainty to their extents. This method provides a conservative and introductory look at what areas remain viable for wind power development. Our analysis found that a limited portion of State waters, restricted to the eastern half of Pamlico Sound, appears feasible for further study although the wind power capacity is marginal. Large areas offshore are potentially well-suited for wind energy development. There are more than 2800 square miles of potential development area in waters less than 50 m deep and within 50 miles of the coastline. Raleigh and Onslow Bay appear to have the most promising wind resource, with capacity factors exceeding 40% in depth greater than 30 m. Winds over the shelf north of Cape Hatteras do not appear as favorable as those to the south, but it is important to note that there are no direct measurements of winds on the northern shelf in water depths less than 45 m. The map below shows the federal MMS lease blocks that do not intersect with any constraint overlay on the wind capacity factor. There are 190 lease blocks with wind power capacity estimated in excess of 35%.

