Wind Power in North America: Status, Problems and Solutions

Martin J. Pasqualetti, School of Geographical Sciences, Arizona State University, Tempe, AZ 85287-0104. Pasqualetti@asu.edu

---

We may be alone in the universe, or maybe we're not. We still do not know. We are certain, however, that no other place in the solar system is likely to add to the reserves of oil, natural gas, coal, or uranium that are already here. We also expect population to rise, especially in the developing countries, as will the demand for energy. Another certainty is that the environmental impacts from our thirst for energy are moving beyond the capacity of natural systems to buffer us from their ill effects.

Many people around the world are working hard to solve the linked problems of energy demand and environmental degradation. While some are looking for technological innovations to expand the contribution of existing resources, others are looking for environmentally sustainable alternative energy solutions. One option is to develop wind power to generate electricity, both because it has become cost competitive with other resources and because it lacks many of their troublesome side effects.

Wind power will not be a panacea, but it can contribute strongly in many places, if we choose those places with care. In many locations there are technical difficulties, transmission bottlenecks, and public resistance. Nonetheless, developing wind power in North America makes a lot of sense. This paper summarizes the present status of North American wind power, identifies its most persistent problems, and suggests some policy-based adjustments.

Status

Wind power in the three countries of North America is in different stages of development. The U.S. leads the three countries with about 11,700 MW connected as of March 2007, and a growth rate of about 26% in the past two years **(Fig 1)**. About 3,000 MW of additional capacity is expected to be installed in 2007. Canada had a total of 1,500 MW connected to the grid by the end of 2006, a doubling of capacity over the preceding 12 months, with

another 500 MW planned for 2007 **(Fig 2)**. In Mexico, where development has lagged due to smaller potential and policy hurdles, most of development is concentrated at the Isthmus of Tehuantepec in Oaxaca where about 90 MW are on line. Most of Mexico's future plans are also located here.[1] Through the country, about 2500 MW are in various stages of development[2] **(Fig 3)**. In all, around 5,000 MW could be now economically tapped. Further exploration could add up to 15,000 MW in new inventories.[3]

California led the wind development boom in North America, and today it has more installed capacity than all of Canada. However, this dominance is fading. The fastest growth has lately been in the Great Plains and its northern cousin, the Canadian Prairies. The Prairies will continue to dominate Canada unless overtaken by development of the huge potential in Quebec and Ontario, as many expect. In May 2007, for example, the Society for Energy Professionals, recommended that Ontario produce 20% of its electricity from wind by 2025.[4] For now, however, the longitudinal swath through the middle of both countries is being favored. In the U.S., for example, three of the largest wind developments—totaling 1281 MW—are located in west Texas, and many other large projects are operating in Minnesota, Iowa, eastern New Mexico, and several other states.

Policy decisions, particularly incentives, influence the speed, viability, and location of wind development in all three countries. In Canada the most promising step has been the implementation of feed-in laws (called Standard Offer Contracts in Ontario).[5] Such SOCs assure developers both a market for their power and a guaranteed price. In the U.S. the most significant incentive continues to be the 1.9 cents per kWh production tax credit, an enticement that is subject to the vagaries of Congress, and is set to again expire at the end of 2008**(Fig. 4)**. Another mechanism used to prompt development is the so-called Renewable Portfolio Standard (sometimes called the Environmental Portfolio Standard), a requirement placed on utilities that can differ from state to state. In Arizona, 15% of electricity generated in 2025 must be from renewable resources for the regulated utilities. In California, the target is 20% by 2010 for most utilities. In Mexico, there are incentives

---

[1] D. Elliott, M. Schwartz, G. Scott, S. Haymes, D. Heimiller, R. George, *Wind Energy Resource Atlas of Oaxaca*, August 2003

[2] Julio A. Valle Pereña, Ministry of Energy, Mexico City, May 21, 2007, personal correspondence.

[3] MA Borja, et al. *Estado del Arte y Tendencias de la Energia Eololectrica*, Universidad Nacional Autonoma de Mexico, Programa Universitario de Energia, Instituto de Investigacions Electricas, Cuernavaca, Mexico.

[4] Society of Energy Professionals, *Getting it Right: A Real World Vision for Ontario's Electricity System for 2025,* 2007: http://www.gettingitright2025.ca/Documents/SEP_Getting_it_Right.pdf

[5] For an overview of these laws, see Paul Gipe, http://www.wind-works.org/articles/feed_laws.html

for small-scale grid-connected pilot projects. In anticipation of large commercial wind developments in Oaxaca, a new 2,300 MW transmission line will be built in the Isthmus by late 2009 to tie the projects into the National Grid.

Problems

Today, after about 25 years of meaningful commercial development of wind power, early financial and technical problems have been largely resolved. Most of the significant remaining problems are tied to environmental costs and public opinion. It is an ironic basis for reticence, considering the relatively minor nature of the impacts of wind power, when compared to those from fossil, hydro, and nuclear generation. Wind turbines produce no oxides of sulfur or nitrogen, no particulates, no mercury, no carbon dioxide, no ionizing radiation, and no waste. They require no water, and few if any of the effects of their construction or operation leave permanent environmental marks.

Nonetheless, with modern wind power still a relatively new factor in the lives of most people, plans for development naturally attract curiosity and close examination. Wind power continues drawing environmental attention, most significantly with regard to its aesthetic impact, but there are several other concerns as well. The list includes hazards to birds and bats, noise, interference with electronic equipment, negative impact on property values, and hazards to airplanes. All these have been addressed by individual scientists, the wind industry, and government agencies.[6]

Bird deaths have nagged wind developers for at least 20 years, more at Altamont Pass near San Francisco than anywhere else. Environmental groups and the wind industry have sponsored studies, and naturally the two sides differ about the significance of wind development to bird safety. However, they do agree on certain things. They agree, for example, that Altamont Pass is unusually abundant in birds because it is along the Pacific Flyway. Second, the land beneath the wind turbines there is rich in food, such as squirrels, that attracts raptors to hunt amidst the turbines. Third, Altamont Pass was one of the earliest major wind installations in the U.S., and it was home to turbines that were smaller and faster than are commonly installed today. Little adjustment is possible on the first two considerations, but new turbines are larger and turn more slowly. For this reason, they are easier for the birds to see and avoid, at least during daylight hours. In

[6] National Research Council of the National Academy of Sciences, *Environmental Impacts of Wind-Energy Projects,* 2007.

addition, the newer turbines are being placed on monopoles, which present fewer attractive nesting places.

Bird deaths may have more public visibility, but worry about bat deaths is on the rise, particularly in Tucker County in eastern West Virginia. As the birds emerge to hunt for insects, they encounter the wind turbines, which they are not always able to detect and avoid, despite their famous night-time sensory equipment. Given the nocturnal nature of bats, the problem is more challenging to study, although some clever schemes have been developed, including the use of radar mapping. The findings have alarmed ecologists, but so far that worry has focused on the mid-Atlantic area, in particular Tucker County. Several options to reduce these deaths are under consideration, including the option of curtailing development in that area. [7]

The remaining environmental concerns have received attention from specific interest groups. For example, the Air Force has had a natural interest in avoiding interference with radar and training missions.[8] On the civilian side, the FAA requires tall towers be painted in blatant colors or mounted with bright strobe lights. Glinting, another source of early complaints, has been reduced by the use of special paint. Even the common objections about noise have subsided—albeit have not disappeared in quieter places—as turbine designs have improved.

Despite various improvements, wind promoters continue to encounter the one persistent and pervasive challenge they cannot completely avoid, aesthetic intrusion. Not only is it unavoidably linked to wind power, it varies from one location to another, and even from one person to another. There is no single or complete solution. We can paint them, quiet them, zone for them, make them visible to airplanes and radar, and we can argue that compared with other sources of electricity, they pose relatively little environmental harm. We can do all those things, but we cannot make them invisible.[9] This reality precipitated a controversy in the mid-1980s in San Gorgonio Pass, near Palm Springs, California, when the city sued the Bureau of Land Management and the County of Riverside for allegedly not following proper environmental procedures. Palm Springs contended that the large collection of wind turbines that had been installed in the dry desert

---

[7] National Research Council of the National Academy of Sciences, *Environmental Impacts of Wind-Energy Projects,* 2007.

[8] DeEllen Brasher, DoD Regional Wind Work Group Update, Nevada Joint Military Affairs Committee, January 2007. http://budget.state.nv.us/clearinghouse/jmac/1-16-07%20JMAC%20WWG%20BRIEF%20-%20DeEllen%20Brasher.pdf

[9] M.J. Pasqualetti, Paul Gipe, Robert Righter, *Wind Power in View: Energy Landscapes in a Crowded World*, Academic Press, 2004.

wash just north of the city degraded the scenic entryway to the resort town. Years of discussions followed, as did several adjustments by the wind power industry and the local planning authorities. These adjustments, which included both technical and policy improvements, were often adopted with positive results by the wind industry elsewhere in the U.S., Canada, and Europe.[10]

Public objection to the visual presence of wind turbines continues in several places. One place is Highland County, Virginia, located a few dozen miles south of bat-plagued installations in Tucker County, WV. Highland County is the most isolated and lightly-settled county in the state. It is also quiet and it has dark nighttime skies, attributes locals would not like changed. A proposal for a ridge-top installation in Highland County has kindled controversy, especially from those whose lifestyle revolves around maintaining the existing near-wilderness conditions.

While Highland County is a sparsely settled area, and the rare environmental conditions found there may warrant a ban on wind power, it is not the only place experiencing opposition. Others include upstate New York, central Vermont, western Pennsylvania, and eastern Tennessee. The controversy in these areas is fairly localized, but one proposal has generated national and international attention on the order of a bare-knuckle fight. The project, called Cape Wind, would be the first in US coastal waters, and it would be the largest such installation in the world **(Fig 5).**

Cape Wind has been attracting attention because of its proposed location between Cape Cod and Nantucket.[11] The plan is to install 130 wind turbines with a total capacity of 420 MW. The debate has raged back and forth for many years between those who contend that wind power is environmentally preferable to any other source, and those who argue that it will threaten avian and aquatic resources, that electrical transformers will leak oil, and that the existence of the towers will interfere with shipping.[12]

Groups on both sides of the argument are fully engaged and committed because of the stakes involved, stakes that extend beyond Nantucket Sound to all future offshore projects along the Atlantic coast of the U.S. and beyond. In the coastal waters offshore of New York and New Jersey, for example, at least nine wind installations are proposed. These proposals include more than 921 wind turbines occupying more than 413

[10] M.J. Pasqualetti, Wind Power: Obstacles and Opportunities. *Environment*. 46(7): 23-38;Wind Energy Landscapes: Society and Technology in the California Desert, *Society and Natural Resources,* 14(8):689-699.

[11] http://www.capewind.org/index.php

[12] www.saveoursound.org

square miles of ocean.[13] Many other projects have been proposed for areas off Delaware and Virginia.

Proponents of offshore wind installations point out their many attractions. Winds tend to be stronger and more consistent than on land, water installations reduce objections from land owners, there is less regulatory variability because most of the best areas are in federal waters, and it is easier to move the massive machinery into place.[14] Whether or not these arguments will tip the scales in favor of Cape Wind is still unknown, but other countries—such as Denmark, Germany, the Netherlands, and the United Kingdom—all have offshore wind developments and more are expected.

While earnest people continue to voice their concerns about Cape Wind's impact on birds, fish, water quality and shipping safety, these issues are relatively minor compared with the overriding objection of aesthetic intrusion. While the physical presence of the turbines is unavoidable, the degree of degradation that would result from Cape Wind is open to interpretation. Simulations show that visibility from people on Cape Cod beaches would be limited to the tops of the turbines, although those traveling on water craft would have a different experience.

That Cape Wind has produced opposition similar to that at Palm Springs 20 years earlier is not a coincidence. Both Cape Cod and Palm Springs have economies based on resort activities, and the people who tend to live in both places are educated, affluent, well-connected, and retired. In other words, they have the intelligence, experience, money, contacts, and time to mount an effective campaign of opposition. Resistance in Palm Springs has subsided, but at Cape Cod it continues. No final resolution is in view.

The U.S. has more wind projects in more places than the other countries of North America, so what happens in the U.S. can affect proposals in the other two countries. So far, however, opposition to wind power in Canada and Mexico has been more subdued than it is in the U.S. In Mexico the wind projects are distant from the major centers of population and recreation. In Canada, public opposition has been small so far, although there is a strong possibility that First Nations people will oppose large developments in Quebec and Ontario when it is on land they claim as their own.

---

[13] Clean Ocean Action website: http://www.cleanoceanaction.org/index.php?id=292

[14] The Energy Policy Act of 2005 authorizes the U.S. Department of the Interior to have regulatory jurisdiction over renewable energy development in federal waters beyond the 3-mile limit of state jurisdiction. DoI has designated its Minerals Management Service (MMS) as the implementing agency for this new authority.

Solutions

The future direction of wind development in North America can be strongly influenced by stressing four principles. One is tied to public attitudes and three are tied to industry attitudes.

NIMBY to PIMBY

Wind power development will advance more rapidly if the prevalent public reaction NIMBY (Not In My BackYard) is replaced by the rarely implemented PIMBY (Please In My BackYard). Such a shift will require a perceptual adjustment, but an important motivation will be to emphasize not just where the wind power development could be most profitable, but where it would be most acceptable. Instead of aiming their sights wherever the wind resource is most tempting, developers should recalibrate their plans to identify places that would meet with less resistance. The simple advice is to avoid NIMBY areas and develop PIMBY areas. This is not a strategy that would have worked in the early days of wind power, but it will today, now that wind power, and its benefits, have become more familiar.

The Prairies and the Great Plains hold the greatest potential for wind development. Whereas issues of limited transmission capability and load persist, there is no question that there is more potential in these areas than anywhere else on the continent. Agricultural land use, as the dominant economic activity in this part of North America, is ideally compatible for wind development, especially financially. In many cases, the additional income that wind power provides can help sustain small family farms, a dying institution **(Fig 6)**. It will likewise provide economic development opportunities to small towns, which are also shrinking and struggling to survive. Already wind development is contributing strongly to the economic well-being of these types of communities in Texas, Iowa, Minnesota, New Mexico, and Colorado, where typical wind leases return $3000-$6000 per turbine per year. Hundreds of millions of dollars of economic benefit are bolstering the communities.[15]

Move Offshore

[15] Larry Flowers, team leader, National Wind Technology Center, "Wind Energy Update", National Renewable Energy Laboratory, 2006.
http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/wpa_update.pdf

With the huge offshore resources of wind power, especially along the populous Atlantic coast of the U.S. and Canada, interest in developing these locations is stronger than ever. Such developments would make more money with less environmental disruption than they would on land, and be faster to install. Moreover, the stronger winds that dominate offshore will require much less area to accommodate an equal amount of generating capacity **(Figs 7, 8)**.

Compatibility Rankings

Currently, the approach to wind development almost always follows the same sequence: Developers identify windy areas. If a few other favorable conditions also exist, they develop a proposal for a project. This approach takes little account of whether wind development in these areas would be compatible with surround land uses. The public scorn for installations in Altamont Pass and San Gorgonio Pass, and near Cape Cod illustrates the drawbacks of this strategy. It could also prove to be especially costly to the wind industry; the Cape Wind proposal, whose location was sure to cause controversy, could slow or halt wind projects all along the Atlantic coast.

An alternative approach is to take a different first step: in advance, rank all wind development areas for their compatibility with existing and planned land use. This method would address the intrinsic conflict potential of wind power by directing development to the most suitable areas, avoiding those that are not. Its advantage would be that it would provide a meta-structure to development by avoiding the most contentious places and increase the portion of our electricity that comes from wind power. The large size and ample wind potential in the US and Canada make it them particularly suited to this approach. There are the four ranks:

Rank #4 locations would be, by consensus, completely <u>off-limits</u>, for example, on the top of Half Dome, Mt. Rushmore, or the Golden Gate Bridge.

Rank #3 locations <u>might</u> be acceptable in certain circumstances. These would be areas such as near Palm Springs that might be acceptable if conditions, public opinion, and planning were carefully considered and coordinated in advance. These would usually be populated areas identified as promising by development companies.

Rank #2 locations would <u>likely</u> be acceptable. These would be areas of good energy resource that are sparsely settled, such as in southeastern Washington and southeastern Wyoming.

Rank #1 locations would be those areas where wind development is not only possible but is overtly requested by residents and land owners, such as farmers in Illinois or Iowa. These areas would be the center of PIMBY.

Morality of Wind Energy Landscapes

Electricity is used by most people with little or no understanding of its origin, either in terms of the mechanics and physics of its creation or the location of the power plants that do the work. The spatial separation of areas of supply from areas of demand has the effect of disassociating cause and effect. This means that consumers rarely must face, accept, or pay for most of the environmental costs of meeting their needs for electricity. This is especially true in the western states where cities are supplied by power plants often hundreds of miles away.

Arizona offers a good example of this phenomenon. While some of the electricity that is used in the cities is generated nearby from natural gas and uranium, the vast majority is transmitted along wires connected to coal power plants that are nowhere in sight. For this reason, the impacts of mining, transportation, combustion, and waste disposal are all absorbed by environments and communities hundreds of miles away, not where the electricity is used. Wind power is different. It has no such spatial flexibility. Coal can be moved by truck, train, or ship. Wind cannot be moved at all.

There is no way to hide wind turbines; they must by nature be out in the open where people can see them, whether that be on ridge tops, on desert mesas, or along interstate highways. For this reason, people cannot help but encounter the source of their electricity, and they cannot avoid taking some personal responsibility for what they see. In the case of wind power, people who live within view of the turbines encounter almost all the impacts resulting from the electricity they are using. Cause and effect—supply and demand—merge, and that is a good thing.[16]

Conclusions

Wind energy is developing rapidly in all three North American countries, and it should continue to do so as long as there are favorable policies from state and national governments, along with continued support of public interest groups. Because of the vast windy areas in North America, especially in the U.S. and Canada, we should expect continued strong growth of the industry, especially in response to the proliferation of renewable energy standards in the U.S., feed-in laws in Canada, and

[16] Morality, Space, and the Power of Wind-Energy Landscapes, *The Geographical Review*, 90(3):381-394, July 2000 .

government support in Mexico. While development is likely to continue raising public opposition where it encounters closely-held personal values, huge contributions from wind power can be expected all across North America, as long as everyone avoids vested self-interest and works toward sustainable compatibility.

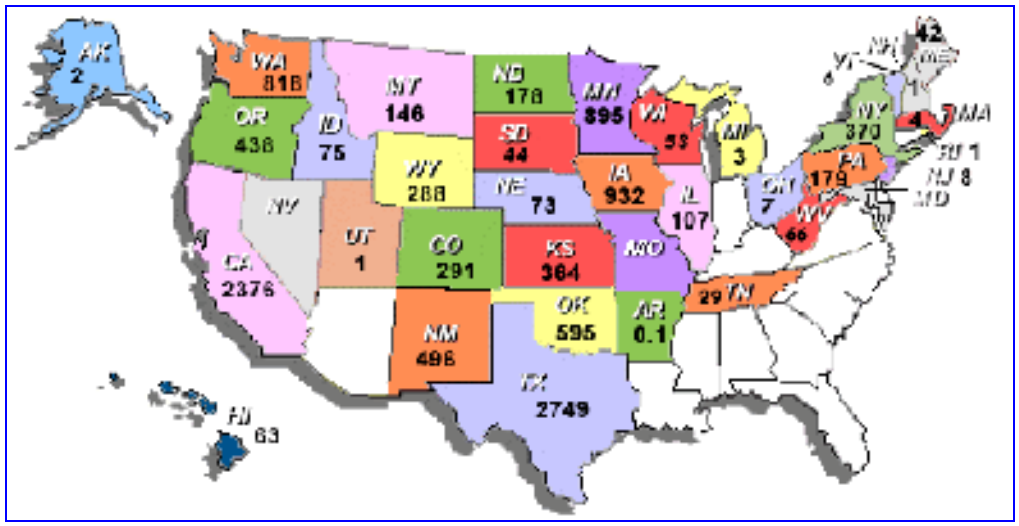

Figure 1 – Installed wind power capacity as of March 2007. Source: NREL

Figure 2 – Installed wind power capacity as of December 2006
Source: Canadian Wind Energy Association, 2006.

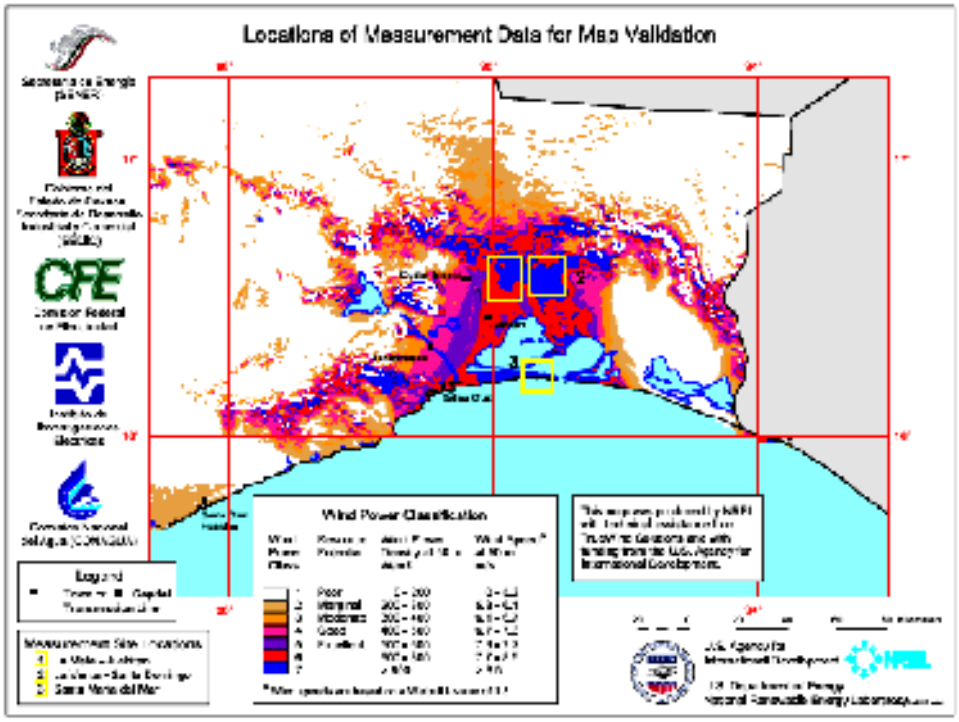

Figure 3 – Wind Power Potential in Oaxaca, Mexico. Source: D. Elliott, M. Schwartz, G. Scott, S. Haymes, D. Heimiller, R. George, *Wind Energy Resource Atlas of Oaxaca*, August 2003

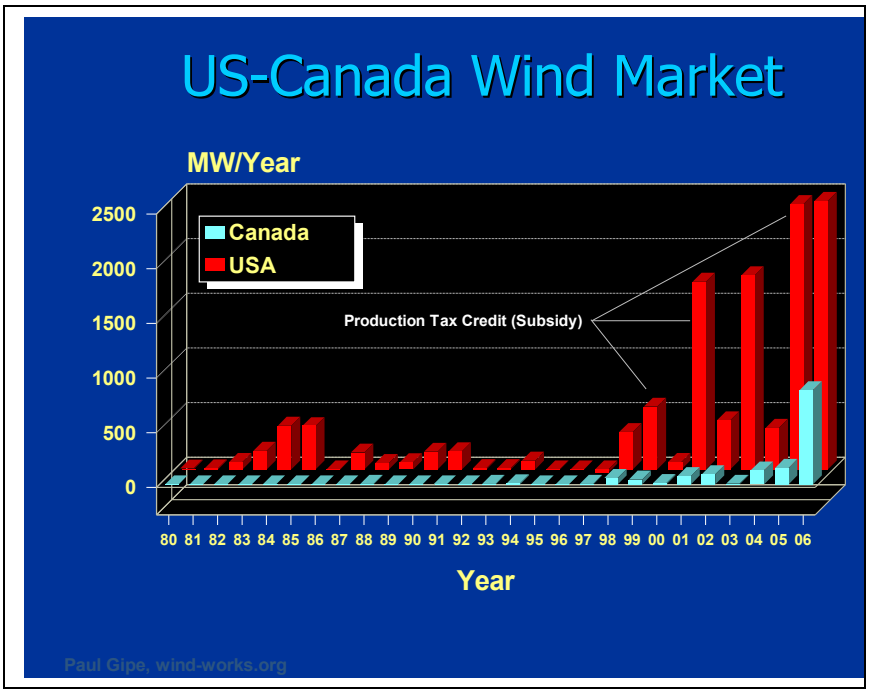

Figure 4 – Incentives move the market. *Source: Paul Gipe, wind-works.org*

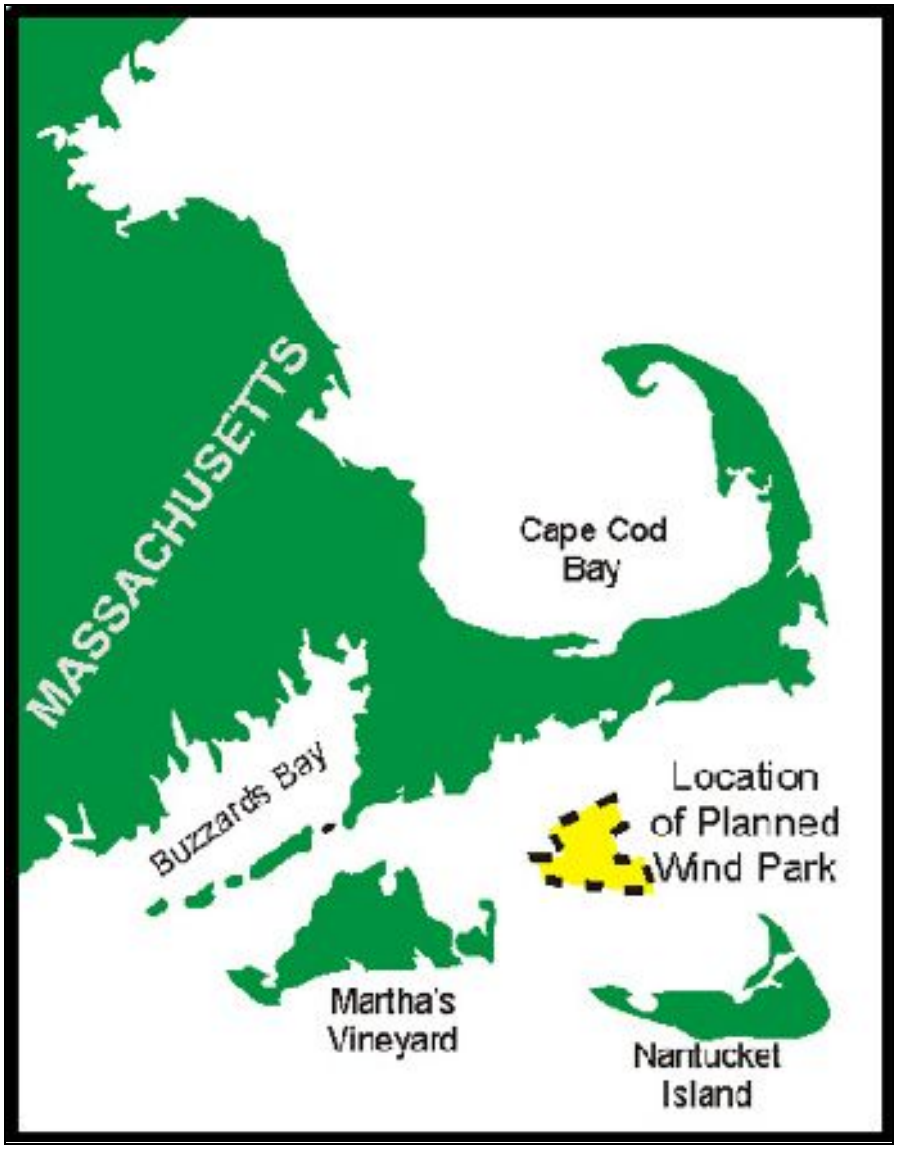

Figure 5 – Location of the Cape Wind development.

Figure 6 – Integrating wind power into small family farms, Dixon, Illinois

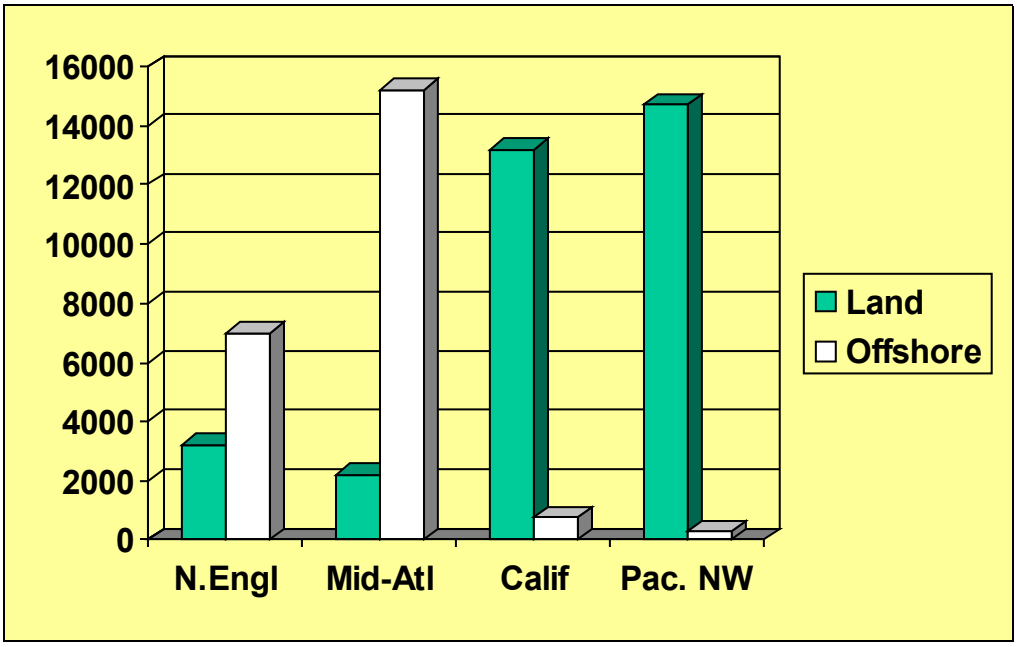

Figure 7 – The greatest potential for offshore wind development is along the Atlantic coast. Class 4+ on land; Class 5+ offshore and water depth <70 ft. No land use exclusions. Source: Bruce Bailey, *Offshore Wind Energy: Status, Issues and Comparisons with on-land Development Potential in Coastal Areas.* Stanford University, 2004. http://gcep.stanford.edu/pdfs/energy_workshops_04_04/wind_bailey.pdf

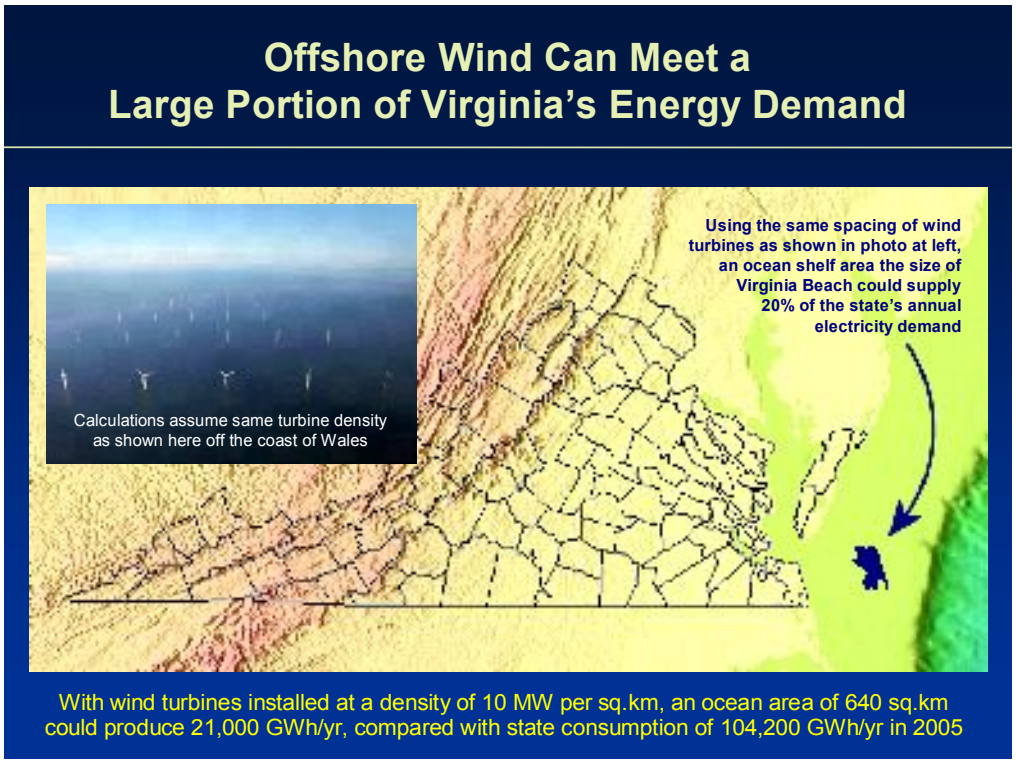

Figure 8 – Offshore compared to on-\shore development
Source: Saifur Rahman, George Hagerman, Manisa Pipattanasomporn, *Wind Energy : Opportunities and Challenges for Offshore Applications*, presentation to IEEE Richmond Section, Sept 7, 2006. http://www.ceage.vt.edu/2DOC/IEEE_Richmond_07Sep06.pdf