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Offshore Louisiana Wind Power

by

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Introduction

The topic of offshore wind generated electricity in Louisiana recently received a lot of attention stemming from several sources. First of all, high fossil fuel prices and steady decreases in the cost of wind power equipment have collaborated to make the economics of wind power feasible in many cases. In fact, in some areas of the U.S., wind power can and does compete with conventional forms of electrical power generation. Second, a recent Stanford University study (Archer and Jacobson, 2003) suggests that the Gulf of Mexico may possess a greater wind resource than previously thought. Finally, a south Louisiana company has proposed placing wind power plants in state and federal waters offshore Louisiana. This article explains the basics of wind generated electricity and how it relates to Louisiana.

Extraction of energy from the wind is not a new idea. Windmills, predecessors to modern wind turbines, have been around since the 6th century when they were used to pump water and grind grain. Wind turbines consist of a blade/hub assembly, gear box, generator, and tower. Wind turbines extract energy from the wind in much the same manner as did ancient windmills, but instead of using the resultant mechanical energy directly, the turbines use it to drive generators that produce electricity.

Utility-scale wind turbines are very large and have blade diameters up to 300 feet and towers that are, roughly, the same height as the blade diameter. A wind turbine with a 260 foot blade diameter would be almost 400 feet tall from ground or sea level to the tip of the blade at the top of its rotation. Larger ones are currently under development. Wind turbine blades are usually made from wood or fiberglass and the towers from steel.

The rated power of current, utility-scale wind turbines ranges from 600 kilowatts (kW) to over 3 megawatts (MW). Units with much higher rated output are being developed. A wind turbine's rated capacity is the amount of power the turbine will produce at a particular wind speed. The actual power output of a particular wind turbine is completely dependant upon how often and how hard the wind blows at a particular location.

The efficiency of a wind turbine is defined as the energy input, i.e., energy contained in the wind, divided by the energy output of the wind turbine. The theoretical maximum efficiency, known as the Betz limit, is 59.3%. The efficiency of a particular wind turbine varies with the wind speed. Current wind turbines have maximum efficiencies of around 50% at a particular wind speed, but are much less efficient at higher or lower wind speeds. Efficiency, however, is not the primary consideration because the wind is free and supply is practically unlimited. By comparison, automobile fuel efficiency would not be a cause of concern if fuel was free and its supply unlimited.

A more meaningful measure of wind turbine performance is the capacity factor. The capacity factor is defined as the ratio of a turbine's actual energy output for the year divided by the energy output if the turbine operated at its rated power output for the entire year. Common capacity factors range from 25% to 40% for wind turbines.

In order to generate significant amounts of electricity, wind turbines are situated in groups called wind farms. The U.S. wind power capacity has increased from 10 MW in 1981 to 6,374 MW (about two-thirds of one percent of the total U.S. electric generating capacity) in 2003. No offshore wind farms exist in the U.S. due to the higher costs involved with placing turbines over water and running transmission cables back to shore, but several are proposed.

Pros and Cons

The lure of wind generated electricity lies in its status as a renewable and non-polluting resource. Wind gets its renewable nature from the sun. Solar radiation heats some parts of the earth's atmosphere more than others creating temperature differences that cause the air to move. As long as the sun burns, there will be wind, making it renewable. Wind is non-polluting; there is no combustion, or any other chemical or nuclear reaction, consequently, there are no emissions and no waste to be disposed.

The main drawbacks to wind generated electricity are its high capital costs and the intermittency of the wind. The high capital costs result from the fact that, like all solar energy, wind is a diffuse source of energy. This means that a large number of wind turbines are required for a wind farm of significant capacity. For perspective, in order for wind to generate 1% of the electricity in Louisiana, 180 two-megawatt wind turbines would be required, assuming a 30% capacity factor for wind. The intermittency of the wind leads to increased operating costs for grid operators. The grid system must maintain a precise balance between the demand for power and the power generated by all of the power plants on a particular grid. Wind speed, hence power output from wind turbines, fluctuates greatly during the day and is unpredictable, making the balancing act more difficult and costly. In general, these costs are referred to as ancillary service costs. Ancillary service costs associated with wind power are not presently well known, but studies estimate a range from 0.15 – 0.55 cents/kilowatt hour (kWh).

Other purported drawbacks of wind power include both aesthetics and associated bird fatalities. The aesthetic value of a wind turbine is subjective. The Cape Cod Wind project off the New England coast is on hold this month because many residents object to the impact a wind farm will have on wildlife, aesthetics and recreation. Louisianians are accustomed to seeing offshore oil and gas structures; wind turbines should not be a problem. In the past, bird kills have been a problem for older wind turbines that rotate fast making the blades difficult to see. Newer, larger wind turbines rotate much slower making the blades easily visible. Bird kill statistics for these turbines average about one bird per turbine per year.

Economics

Installation costs for utility scale wind farms are in the neighborhood of $1000/kW for onshore systems and $1500/kW or more for offshore systems. By comparison, the capital cost for conventional natural gas turbine capacity is about $350/kW. It should be noted however, that almost no one is currently considering building any natural gas power plants due to high natural gas prices. If natural gas prices remain high, as most analysts predict, most new electrical generation capacity will be built using coal and nuclear fuel. A new coal power plant would cost about $1000/kW and a nuclear plant about $1500 - $2000/kW. Given these prices and, in general, less red tape and permitting problems associated with wind than with coal and, especially, nuclear, and lower operating costs with wind, i.e., no fuel costs and low maintenance costs, wind power starts to become attractive.

The direct cost is ultimately what determines the competitiveness of a particular type of power production. Over the last 15 years, the direct cost (cents/kWh) of wind power has fallen 85%, and, in some cases, is competitive with coal and natural gas power. The reductions in cost have resulted mainly from the development of larger, more efficient turbine designs. Another key factor that makes wind power more competitive is the recent price increases for conventional fuels. Prices for wind energy are usually quoted including a federal production tax credit (PTC). The PTC was enacted in 1992 with the Energy Policy Act and was recently extended through 2005 and raised from 1.5 to 1.8 cents/kWh. The PTC, which is not applicable to existing production facilities, is available to companies for new production of renewable energy including solar, biomass, geothermal, and wind power. Future advances in turbine technology are expected to reduce the cost of wind power even further and to eliminate the need for the PTC, yet the ability of wind power to be competitive ultimately depends on the wind resource.

Wind Resource

The most fundamental and significant cost factor of wind generated electricity is the wind itself, specifically, how often and how hard it blows. For a given location, values for the speed and frequency of the wind must be known or assumed in order to calculate the cost of wind generated electricity. To a degree, a wind turbine will produce more power with higher wind speeds. More power per turbine equals lower costs. The power available in the wind is proportional to the cube of its velocity, so if the wind velocity doubles, the power available would increase by a factor of 8. This means that a small increase in wind velocity will significantly increase the power output of a wind turbine. Wind resources are classified by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) (Table 1.). Wind speeds are given at a height of 50 meters. This is because wind speed increases with height above ground or sea level. In general, a class 4 wind resource is required for a commercially viable wind farm.

Wind Power Classification		
Wind Power Classification	Resource Potential	Wind Speed @ 50 meters (mph)
2	Marginal	12.5 - 14.3
3	Fair	14.3 - 15.7
4	Good	15.7 - 16.8
5	Excellent	16.8 - 17.9
6	Outstanding	17.9 - 19.7
7	Superb	19.7 - 24.8

Table 1. Standard Wind Resource Classification

Louisiana's onshore wind resource has virtually no potential for wind power development. The wind speed and frequency is not sufficient enough to make wind power economical. This is fully documented in *Evaluating Wind Energy Potential in Louisiana* (1981). Louisiana's offshore wind resource is, to date, still somewhat unknown. Stanford University (Archer and Jacobson, 2003) suggests offshore Louisiana may have great potential with several areas containing class 7 winds. A recent analysis of the available data completed by NREL (M. Schwartz, unpublished data) for the Louisiana Department of Natural Resources concludes that the offshore Louisiana wind resource is generally class 3 or 4. Wind speed data does not exist in which the measurements have been taken at the hub height of modern wind turbines, about 80 meters. To begin to understand the differences among the conclusions of these studies it is important to note the chosen methodologies used to extrapolate measured wind speeds from the height at which they were taken to the hub height of a wind turbine. Whereas Stanford developed an entirely new method for this calculation, NREL used a pre-established method which Stanford researchers claim underestimates the wind speeds.

What this means to Louisiana

It bears repeating that the ability of wind power to be competitive ultimately depends on the wind resource. If the offshore Louisiana wind resource proves to be extraordinary, as some predict, the potential benefits to Louisiana by tapping into that resource are many.

The proposed project, previously described, involves placing wind turbines and related equipment on abandoned oil and gas structures, as well as, on new purpose-built structures offshore of Louisiana. If built before the Cape Wind Project, this project would be the first offshore wind farm in the U.S. A typical wind farm would consist of, approximately, 25 two-megawatt turbines spread out over about 3 square miles. The project would provide power for onshore uses and, perhaps, for offshore uses including oil and gas exploration and production, as well as for LNG facility operations. To the extent that it is feasible to use abandoned oil and gas structures, such use could save owners the expense of dismantling these structures once oil and/or gas production ceases. It would also keep the structures in place for any future advances in oil and gas extraction technology which would allow previously uneconomically recoverable oil and gas to be recovered.

Many states are implementing a renewable portfolio standard (RPS). A RPS requires affected electricity distributors to acquire a certain percentage or quantity of their electricity from renewable resources. This requirement makes way for a renewable energy trading market in which a renewable energy generator can sell renewable energy credits (REC), or green tags. This would potentially make RECs from Louisiana offshore wind farms exportable to distributors in other states that have to satisfy a RPS but do not have access to an economically viable renewable resource in their own state.

Offshore wind energy offers Louisiana an opportunity to sustain the oil and gas service industry as many of the same service industries and technologies used in the construction of offshore oil and gas structures can be utilized directly, or be easily adapted to construct offshore wind farms. Louisiana has a long history of being a leader in energy production and technology. As oil and gas production in the state continue to decline, offshore wind energy could help Louisiana maintain its leadership role in the energy industry.

References

1. Archer, C. L. and M. Z. Jacobson. 2003. Spatial and temporal distributions of U.S. winds and wind power at 80 m derived from measurements. http://fluid.stanford.edu/~lozej/winds/2002JD002076.pdf. Accessed 12-01-04.

2. Mike French, Evaluating Wind Energy Potential in Louisiana (technical report, Louisiana Department of Natural Resources, Research and Development Division, 1981). http://dnr.louisiana.gov/sec/execdiv/techasmt/data/alternative/windreport1981.html

For more information on wind energy:

- **American Wind Energy Association**
  http://www.awea.org/
- **National Wind Coordinating Committee**
  http://www.nationalwind.org/default.html
- **U. S. Department of Energy/Energy Efficiency and Renewable Energy**
  http://www.eere.energy.gov/RE/wind.html
- **National Renewable Energy Laboratory/National Wind Technology Center**
  http://www.nrel.gov/wind/