U.S. Offshore Extreme Wind Analysis Based on Hurricane Return Probabilities

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Overview

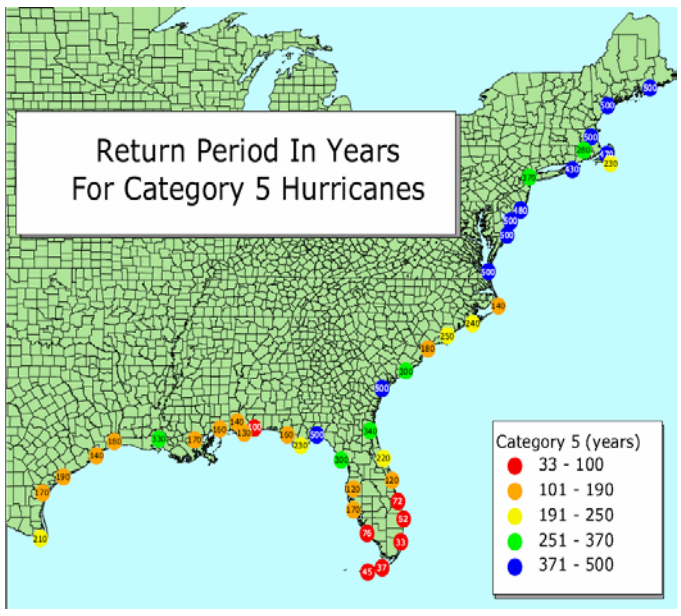
Hurricane return periods can be used to provide an estimate of extreme wind speeds. The results for 50-year and 100-year extreme wind speeds for various areas of the Eastern and Southern United States coasts are shown.

Background

For any wind development project, there is a need for information on the 10-minute average extreme wind speed for the development site to determine suitability for wind turbine technologies in accordance with loading guidelines, such as those of the International Electrotechnical Commission (IEC) [1,2] and the American Petroleum Institute (API) [3]. While guidelines have not yet been accepted for offshore wind development in the U.S., the current IEC standards for on-shore wind development dictate the need for information on this extreme wind speed value over a 50-year period. The table below shows the 10-minute average maximum 50-year extreme wind speeds for the IEC 61400-1 and draft offshore 61400-3 wind classes [1,2]:

Wind Turbine Class	I	II	III	S
V_{ref} [mph]	111	95	84	Specified by Designer

It is anticipated [4] that 100-year extreme wind information may be necessary for U.S. offshore wind guidelines due to a similar existing requirement for U.S. offshore oil and gas development governed by API RP-2A [3]. The National Hurricane Center has estimated hurricane return periods for coastal cities across the United States, such as those shown for a category 5 hurricane in the figure below [5].



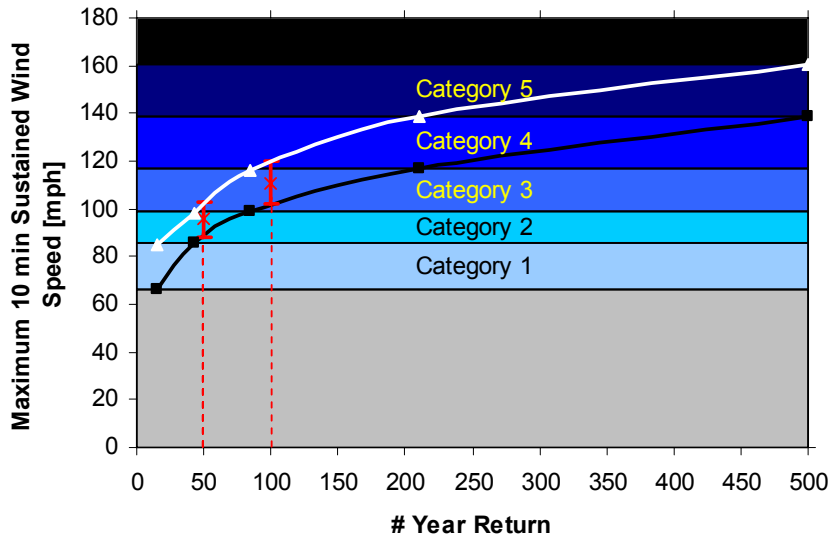
Hurricane return periods are the frequency at which a certain intensity or category of hurricane can be expected within 75 nm (86 statute miles) of a given location. While this information is based the Saffir-Simpson Hurricane Intensity Scale, which uses 1-minute average wind speed information, there are ways to effectively convert these averages to the 10-minute averages used in the IEC standards. Powell et al. recommend a 12% reduction in wind speed when going from a peak 1-minute to a peak 10-minute average [6]. This means the 111 mph maximum 50-year extreme wind speed for an IEC class I turbine would correlate to a 124 mph 1-minute averaged wind speed, which is a category 3 hurricane as shown on the Saffir-Simpson scale below [7]:

Saffir-Simpson Category	*Maximum 1-min sustained wind speed* [mph]	*Maximum 10-min sustained wind speed* [mph]
1	74 - 95	66 - 85
2	96 - 110	86 - 98
3	111 - 130	99 - 116
4	131 - 155	117 - 138
5	156+	139+

[1] International Electrotechnical Commission (IEC), IEC 61400-1 3rd Ed. 2005, Standard Wind Turbine Generator Systems, Part 1: Safety Requirements,
[2] International Electrotechnical Commission (IEC), IEC 61400-3 Ed.1, Wind Turbines – Part 3: Design requirements of offshore wind turbines, IEC TC 88 WG3 Committee Draft, December 2005.
[3] American Petroleum Institute (API), Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design, API RP-2A-WSD, 21st Edition 2000.
[4] Saigal, et al. 2007. *Comparison of Design Guidelines for Offshore Wind Energy Systems, 2007 OTC:* 18984-PP.
[5] National Hurricane Center, Hurricane Preparedness, Return Periods http://www.nhc.noaa.gov/HAW2/english/basics/return.shtml
[6] Powell, M.D., S.H. Houston, and T.A. Reinhold, 1996:"*Hurricane Andrew's Landfall in South Florida, Part I: Standardizing measurements for documentation of surface wind fields."* Wea. Forecast. *v.11, p.329-349*
http://www.aoml.noaa.gov/hrd/tcfaq/D4.html
[7] NOAA Hurricane Research Division, FAQ# D1, http://www.aoml.noaa.gov/hrd/tcfaq/D1.html

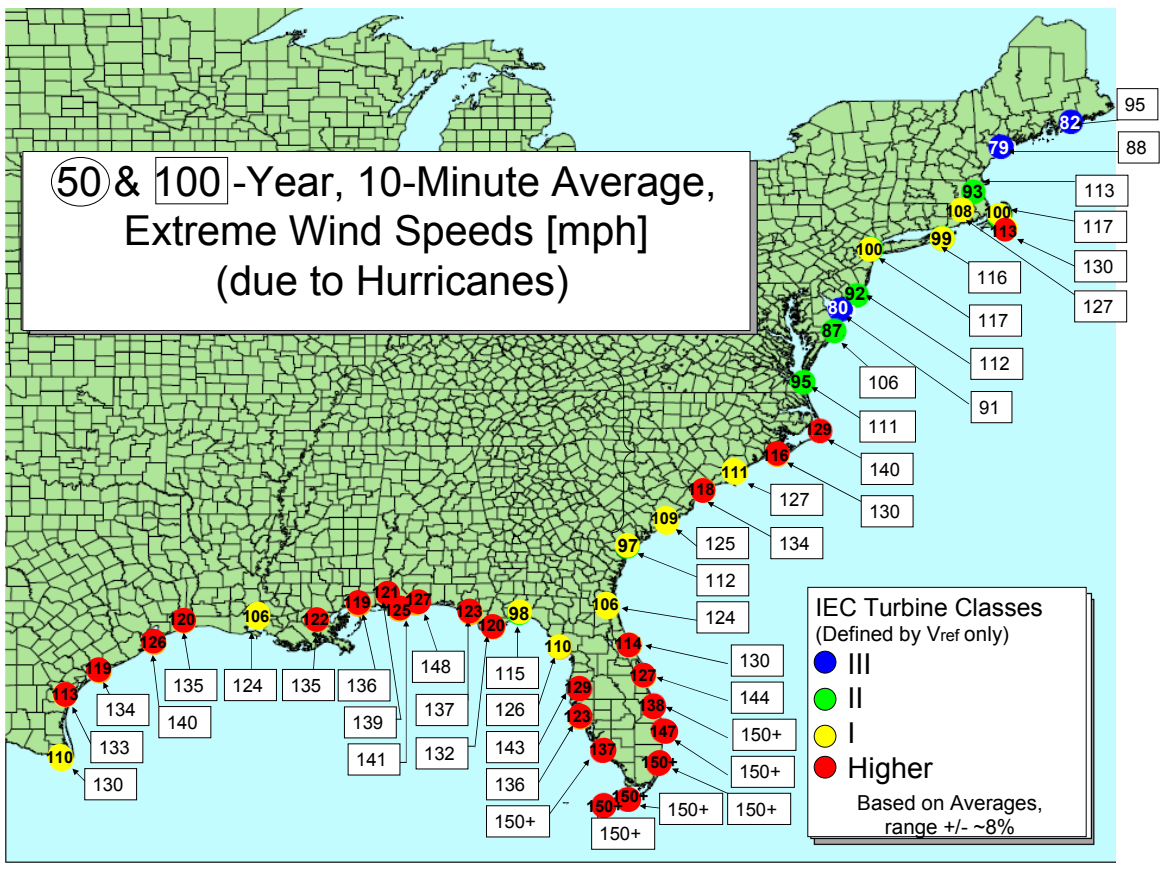
Analysis

Using the information provided in the tables above and from the NHC hurricane return periods [4], 50-year and 100-year 10-minute sustained average extreme wind speeds can be estimated for sites along the Eastern and Southern U.S. coasts. Shown in the figure below is an example of this analysis for the case of Virginia Beach, VA. Hurricane return periods of 15, 43, 84, 210, and 500 years for hurricanes of categories 1-5 respectively, are plotted versus the lower and upper limits defined in the Saffir-Simpson scale (converted to 10-minute averages as described above). The points where the resulting curves cross the 50 and 100 year return lines defines the range of extreme wind values for this site. The mid-point of the range is denoted by an x and is equal to 95 and 111 mph, respectively for this location.



Using this approach, the mid-point 50-year extreme 10-min average wind speeds have been superimposed on the NHC hurricane return period map below. Color coding for these data points is based on which minimum class of turbine from IEC 61400-3 would be suitable for each site. The 100-year extreme10-min average wind speeds are also noted (in boxes) for each location. It is interesting to note that the coastlines along the East coast with a northwest or northern slope have a significantly lower occurrence of hurricane strikes and therefore lower extreme winds speeds from hurricanes. Many sites which may have high potential for wind development in other regards, have extreme wind speeds beyond the current standards of wind turbine technology (those points shown in red). Note these values are an estimate and have a +/- 8% range on them to account for the range of wind speeds in the Saffir-Simpson Scale used in the calculations.

50 & 100-Year Extreme Wind Speeds



Background adapted from http://www.nhc.noaa.gov/HAW2/english/basics/return.shtml
Note: These values are approximations, and should be site specifically verified for projects under development.

Conclusions

Extreme wind speeds are just one of many factors to consider in siting offshore wind farms. With the prevalence of hurricanes along the coasts of the United States, it is prudent to consider locations with limited probability of a major hurricane strike over a 50-year period considering current wind turbine survival speeds in the Category 3 range.

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