Offshore wind power resource in the Virginia Coastal Ocean

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Virginia Coastal Ocean

The bathymetry of the Virginia coastal ocean (Fig. 1) is relatively simple and smooth over its 150 km length and 100 km width. The average depth is 30 m with a bottom covered by coarser sediments that are 95 % sand.

The purpose of this study was to determine the characteristics of the wind, in the Virginia Coastal area including mean conditions for wind power production and extreme events analysis for foundation design.

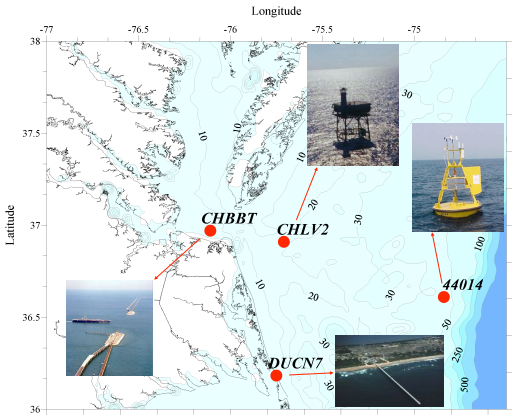

Figure 1.-Virginia Coastal Ocean, including the shelf bathymetry and the location of meteorological stations in the study area.

Methodology

Wind characteristics were determined using hourly data from meteorological stations and daily wind satellite data.

Wind data from selected stations (red dot in Fig 1) were obtained from the National Data Buoy Center (NDBC). The four stations selected were: the buoy located 64 nm off Virginia Beach (buoy 44014), the Chesapeake Light Tower (CHLV2), the Chesapeake Bay Bridge Tunnel (CHBBT), and, station DUCN7 - Duck Pier, North Carolina. The hourly averaged data was available for 18 year period (1990 to 2007), except for the CHBBT (1992 – 2007). The data was adjusted from the measurement height to a notional hub height of 50 m, using a power law coefficient of 0.11.

For each station the annual, monthly and hourly average of the wind Power Density (watts/m^2) was calculated. Additionally the hourly average was determined for the four seasons: winter (Dec, Jan, Feb), spring (Mar, Apr, May), summer (Jun, Jul, Aug), and fall (Sep, Oct, Nov).

Spatial patterns of seasonal wind power density were determined using daily images of level 3 satellite wind measured by QuikSCAT from Jan 2000 through Dec 2007.

Extreme events are highly variable in terms of intensity and sequencing. By definition, they are rare but have a major impact on design. Extreme mean wind speeds (10-minute average) and the maximum 2-second gust was determined for each time series.

Results and Discussion

The values of extreme wind speeds are similar at all stations in the Virginia coastal area, increasing towards the south, due to the greater prevalence of landfalling hurricanes along the North Carolina Outer Banks. At CHLV2, the extreme wind values at 50 m height for 25, 50 and 100 years return period are 35.4, 37.5 and 40.0 m/s respectively for mean wind speed and 40.0, 42.4 and 44.9 (m/s) for wind gust.

The wind rose (Fig. 3) shows that during the 17 years of data analyzed, the predominant wind direction in the area is along the coast from N-NNW (prevailing in winter) and from SSW (prevailing in summer). The annual average wind speed for CHLV2 was 7.6 m/s with speeds greater than 11 m/s 17% of the time and less than 3.6 m/s 16% of the time.

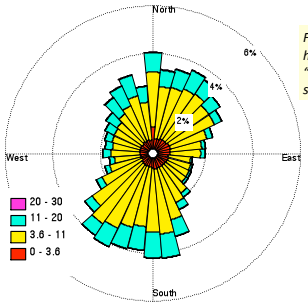

Figure 3.- Wind rose at notional 50 m hub height for CHLV2. Wind direction is "blowing from". Annual average wind speed is 7.6 m/s.

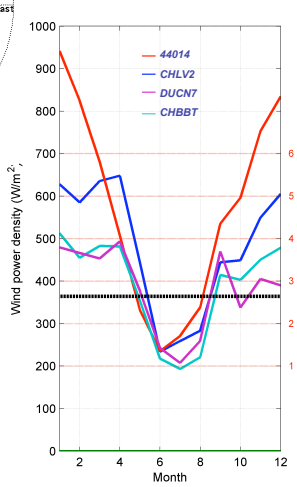

Figure 4. Wind power density (W/m^2) monthly averages for Buoy 44014, CHLV2, CHBBT and DUCN7 stations.

Figures 2, 4 and 5 show that the average wind power density increases with increasing distance from the coast, being greatest in winter and least in summer. At buoy 44014 and CHBBT the highest wind speeds occur at midday and the lowest at night. The opposite pattern is observed during summer at the same stations and at the CHLV2. The pronounced mid-day drop at CHLV2 in spring, summer, and fall may be due to offshore divergent wind zone of sea breeze circulation cell. Satellite scatterometer-derived winds show similar values and seasonal patterns as the meteorological station measured winds.

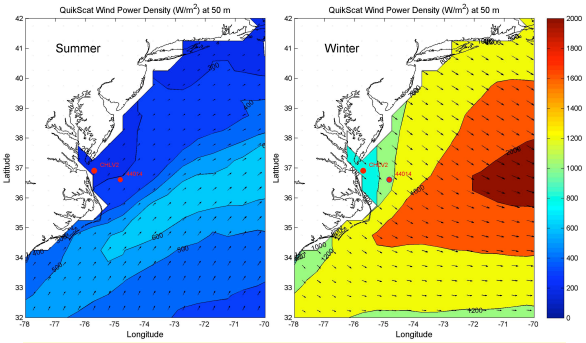

Figure 5. QuikSCAT satellite wind maps. Average wind power density (W/m^2) for summer and winter (period 2000-2007) at 50 m height, and direction of wind stress.

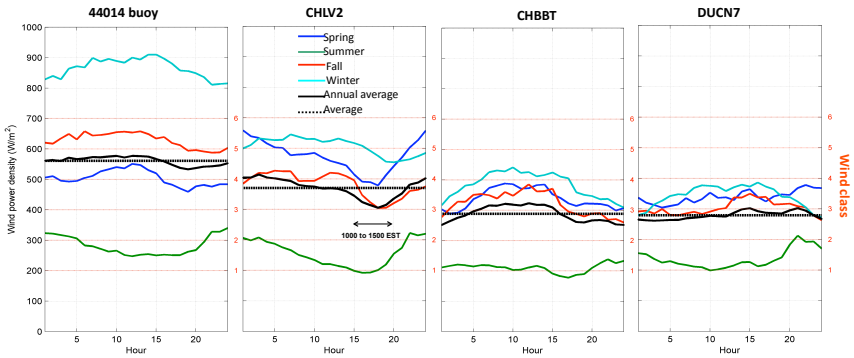

Figure 2. Hourly average wind power densities (W/m^2) for Buoy 44014, Chesapeake Light Tower (CHLV2), Chesapeake Bay Bridge Tunnel (CHBBT) and DUCK pier, NC (DUCN7) stations by season and for year. Hour of day is in GMT (EST-5 hr).

The low frequency of calms, the high frequency of wind class 3 and above, the low impact of hurricanes and the shallow depths of the Outer Continental Shelf, make the Virginia coastal ocean a unique place for offshore wind energy development.