LETTER

Reply to Powell and Cocke: On the probability of catastrophic damage to offshore wind farms from hurricanes in the US Gulf Coast

As a result of Powell and Cocke's letter (1) regarding our paper on the hurricane risk to offshore wind turbines (2), we have reviewed and updated some of our analysis. However, our conclusion remains that wind turbines in hurricane-prone areas face extreme wind conditions significantly different from those for which offshore wind turbines are currently designed; some of this risk can be mitigated through engineered mechanisms:

i) Powell and Cocke (1) observe that we interpreted the "maximum sustained wind speed" of US hurricanes as 10-minute averages when they are actually 1-min averages. We recalculated our results with this correction and have plotted them in Fig. 1*B*.

ii) Although newer hurricane data are considered more reliable, we find the period of HURDAT (Hurricane Database) hurricane intensity data does not significantly change the fitted distribution. A generalized extreme value (GEV) distribution fit to hurricane data from 1978–2008 is not statistically different from a GEV distribution fit to hurricane data from 1851–1977 at the 95% confidence level, according to a two-sample Kolmogorov–Smirnov test.

iii) Although the average landfall intensity of hurricanes near Galveston is 65% of their lifetime maximum, the GEV distribution for hurricane intensity in the region around Galveston in our paper is statistically indistinguishable from the GEV distribution Powell and Cocke fit to intensities of land-falling hurricanes in the Gulf of Mexico (table 1 of ref. 3). Thus, the GEV distribution for Galveston does not change if we assume the land-falling intensity of a hurricane anywhere in the Gulf of Mexico is drawn from the same distribution instead of assuming that hurricanes passing through a region around Galveston maintain their peak intensity to landfall, as we previously assumed.

iv) Powell and Cocke (1) are correct that the maximum wind area is significantly smaller than we previously assumed. We recalculated our results with the correct averaging period and a wind field model proposed by Holland et al. (4), and have plotted them in Fig. 1*C*. We calculated the wind fields at 29.15° N, 94.66° W for all storms that make landfall in Galveston County with hurricane intensity (9 storms, 1900–2008) using the relationship for radius of maximum winds proposed by Powell et al. (5) if central pressure is available, or a radius of maximum wind of 33 km (the median size of Gulf hurricanes from figure 37 of ref. 6) if central pressure is not available. We performed a Monte Carlo simulation of 200,000 years using a Poisson landfall rate of 9/107, a GEV fit of Gulf of Mexico landfall maximum winds (table 1 of ref. 3), and wind fields randomly selected from the nine land-falling hurricanes. There still remains a 5% probability that more than 10 turbines will be destroyed during the lifetime of the farm. We propose that this risk is sufficiently high to merit the design of turbines better suited for hurricane conditions. The costs of engineering improvements will ultimately have to be compared with the cost of low-probability but catastrophic events. Research on this area is underway, and we are happy to be involved in the discussion.

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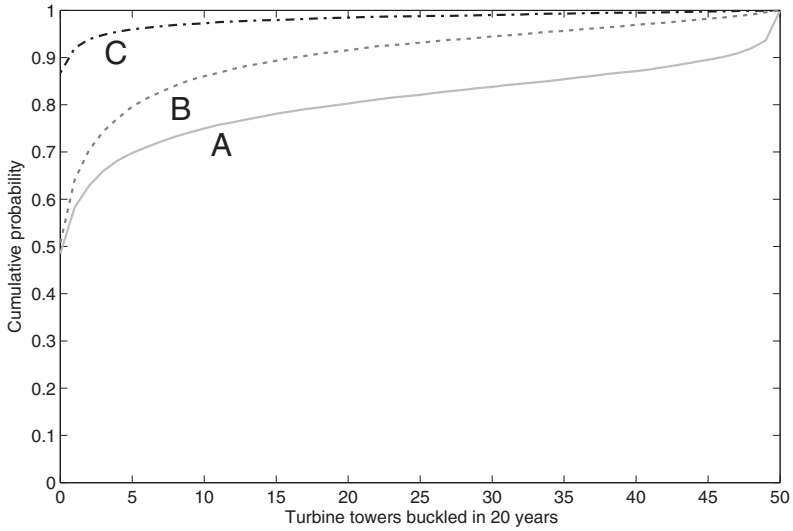

Fig. 1. Cumulative distribution of the number of turbine towers in a 50-turbine wind at 29.15° N, 94.66° W buckled in 20 y if buckled towers are not replaced and there is no active yawing. (*A*) Original results for Galveston published in figure 2 of ref. 2 are shown. (*B*) Results using the correction for 1-min average wind speeds are plotted. (*C*) Results using that correction and a wind field model are shown.