Hurricane risk assessment of offshore wind turbines under changing climate

Reda Snaiki

Université du Québec à Chicoutimi, Québec, Canada

Teng Wu

University at Buffalo, NY, USA

Contact: reda_snaiki@uqac.ca, tengwu@buffalo.edu

Abstract

Offshore wind energy is attracting increasing attention across the North America. However, the offshore wind turbines along the East Coast are extremely vulnerable to hurricane-induced hazards. The vulnerability to hurricanes is expected to change due to global warming's effects. This study quantifies the risk of floating wind turbines (FWTs) subjected to hurricane hazards under current and future climate scenarios. The hurricane hazard estimation is achieved using a hurricane track model which generates a large synthetic database of hurricanes allowing for accurate risk estimation. The structural response of the FWTs during each hurricane event is obtained using an efficient physics-based 3-D model. The case study results involving a parked FWT indicate that the change in hurricane-induced risk, evaluated in terms of the magnification factor, to the FWTs would significantly increase with the intensity measure.

Keywords: Floating wind turbines; hurricanes; risk; waves; synthetic tracks; fragility curves.

1 Introduction

Wind energy is considered as one of the main renewable energy sources which attracts huge investments to improve the current technologies and maximize its profitability. Floating wind turbines (FWTs) is an example of these new technologies which are designed to exploit the abundant and strong wind compared to land conditions, particularly over deep water. However, they are exposed to not only wind excitations but also to waves which might induce larger structural response and possibly failure especially in the US east coastlines which are vulnerable to devastating hurricanes. With a lack of or non-existence of a well-established practice for hurricane risk estimation on FWTs, it is of great significance to develop a framework suited for the efficient and accurate estimation of such risk. This situation might get even complicated in the light of a changing climate scenario which might induce more damage and therefore higher risk of failure to the FWT platforms.

This study developed a methodology for the estimation of hurricane-induced risk on FWTs in terms of the mean annual rate of limit state exceedance of the hurricane-induced hazard. The proposed framework is structured around three main components, namely hazard intensity estimation, structural response and fragility curves

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