Environmental Considerations for Offshore Wind Farms in the Caribbean: A Puerto Rican Case Study

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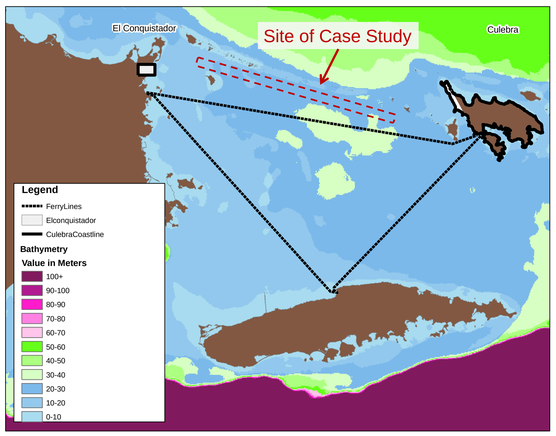
Introduction

Wind power is a rapidly growing renewable energy source that the Department of Energy envisions will produce 20% of the electricity demand in the United States by 2030. It is especially attractive as a potential energy source for Small Island Developing States (SIDS) in regions such as the Caribbean where electricity costs are very high due to the need to import fossil fuels to meet the electricity demand.

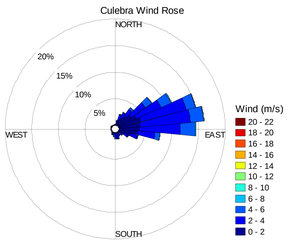
Offshore wind farms have the potential to lower the cost of energy with a minimal land footprint, but necessitate a thorough understanding of the environmental impacts due to their proximity to some of the most biodiverse and fragile ecosystems in the world. In this work, a team of researchers from various fields investigate the potential impact of an offshore wind farm located in the waters between the Puerto Rican mainland and the island of Culebra. We use a multi-disciplinary approach to understand the requirements of this project from ecological, socio-economic, engineering and policy perspectives.

The Caribbean Environment



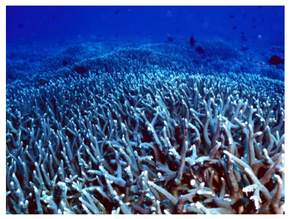
Above: Puerto Rican Bathymetry, blue color depicts depths suitable for monopile type foundation.

Right: The wind rose showing direction and wind speed for a site near Culebra; note the strong Northeasterly trade winds.



Environmental Assessment

The flora and fauna of the Caribbean are uniquely different than that of any other global location in which offshore wind development has occurred to date. Tropical island ecosystems have a high degree of biodiversity and endemic fauna, so impacts can easily disrupt delicate ecosystem function and affect populations. In Puerto Rico, special attention needs to be paid to critical coral, seagrass, mangrove, and sand flat habitats, as well as numerous commercially valuable fish and arthropods that are already facing over-exploitation. The Puerto Rican waters are home to endangered sea turtles, manatees, and humpback whales. Endangered terns and pelicans forage in the water in the daytime, while the night skies are home to 13 species of tropical bats, and uncounted numbers of migratory songbirds.



Staghorn Coral (T)
Acropora cervicornis

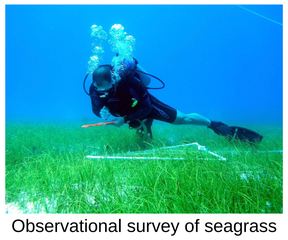
Roseate Tern (E)
Sterna dougallii

Antillean Manatee (E)
Trichechus manatus m.

Parnell's Mustached Bat
Pteronotus parnellii

A wide range of methods need to be used to determine which species are present in a proposed wind area, including boat-based visual surveys and radar for marine birds, and passive acoustic monitoring devices to detect ultrasonic calls from bats and nocturnal flight calls of migratory birds. In the water, visual scuba surveys can identify which habitats and fishes are present, and acoustic tags can be used to monitor sea turtle movements.

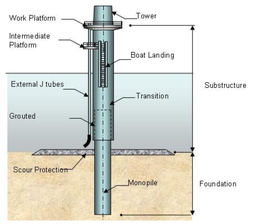
Boat-based visual survey in Puerto Rico.



Observational survey of seagrass habitat (photo courtesy NOAA).

Engineering Assessment

Piling during construction of monopile foundations causes source levels of 215 dB re 1μPa 1 m [1], causing temporary marine mammal avoidance. Furthermore, the transmission line installation alters habitat, and may cause species to be crushed or asphyxiated from sedimentary plumes. During operation, these lines create electromagnetic fields & dissipate heat that must be accounted for in the design.



Monopile Foundation.

Avoidance and Minimization Technologies

Phase	*Species*	*Technique*	*Results*
Construction	Marine mammals	Air bubble curtains	14 dB mean sound attenuation [2]
	Marine mammals	Vibratory hammers	Untested for this application, likely quieter [1]
	Benthos	Proper siting of transmission line routes and configuration; adequate burial depth	Minimizes critical habitat alteration, electromagnetic fields and heat dissipation to environment
Operation	Bats	Increase cut-in wind speed/ feather blades at low wind speeds	Up to 72% reductions in mortality while 1-3% loss in annual power generation [3].
		High frequency ultra-sonic deterrents	Works well under lower wind speeds and clear weather [4].
	Birds	Automated radar controls to curtail power during peak migration periods / adverse weather	Demonstrated but not in operation [5]

References

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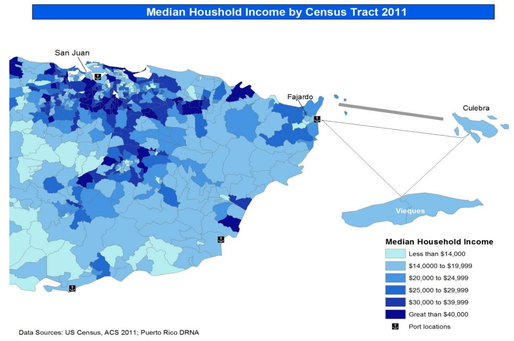
Socio-political Assessment

Caribbean states are economically challenged by isolation and small scale. Development is heavily reliant upon natural marine and coastal resources. Primary and secondary data sources are used to understand the socio-economic impacts of OWED. Preliminary survey findings indicate that public attitudes towards OWED are favorable but cautious. Electricity produced from the project will be substantially lower than existing rates and a number of direct/indirect economic impacts are expected. However, the larger question pertains to how OWED may affect vital industries (tourism, fishing). Engagement of key public and private stakeholders will prove critical in gaining support for OWED and minimizing negative socio-economic impacts.

Key socio-economic concerns

Competing resource uses	Public participation
Economic (+,-) (direct, indirect)	Utility system (prices, infrastructure)
Historic, cultural, env. justice, safety	Visual (viewshed)
Port area(s)	



Conclusions

With this information we are creating a guiding document for conducting offshore wind environmental impact studies in the Caribbean. This is the first step towards creating an interdisciplinary "best practices" guide for the development of offshore wind projects in tropical waters. The guides will help empower small islands to create their own clean energy and reduce their dependence on fossil fuels, thereby allowing them to invest in the sustainability of the critical environments on which they depend.

Acknowledgements

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