Undergraduate Thesis Prospectus

Active Stabilization of an Offshore Wind Turbine Platform

(technical research project in Mechanical Engineering)

The Struggle over Offshore Wind Energy in Virginia

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How can the United States become more dependable on reusable energy?

Rapid adoption of renewable energy sources can mitigate climate change. In the U.S., 19.8 percent of electric power is generated from renewable energy sources; hydropower and wind account for most of the renewable share. The Center for Climate and Energy Solutions forecasts a 2.4 percent annual rate of growth of renewable energy, reaching 35 percent by 2030 (CCES, 2021). Most of the increase is expected to come from wind and solar energy. Yet turbine farms demand extensive land, and in densely populated areas, where grid capacity is most needed, available land is scarce. Offshore wind farms, however, do not compete for scarce land and do not subject local populations to noise pollution.

Active Stabilization of a Wind Turbine Platform at Sea

How can a wind turbine platform at sea be actively stabilized to increase energy production efficiency?

Introduction

This project in under the guidance of Professor Michael Momot in the mechanical engineering program. Team members include Conner Steenrod, Ryan Anderson, Matthew Metcalf, and Daniel Dereberry.

An offshore wind turbine as opposed to one on land possesses the risk of swaying or tipping due to natural elements such as ocean waves, currents, and winds. To be most efficient, the wind turbine should be kept in a level, steady state position which proves to be difficult in the deep ocean. Stabilizing the turbine platform is essential for energy production from wind. Just over six percent of global electricity in 2020 was produced by wind which accounts for 743 GW

(CCES, 2021). Only 35.6 GW of that is produced from offshore facilities, although there is unlimited viable offshore area. Additionally, onshore turbines can be an eyesore creating visual and noise pollution to the large areas the farms need, as well as harming the wildlife in their area. Thus, there is a need to have precise and efficient stabilization methods for offshore turbine platforms.

Project Specifics

The technical project involves a 3D printed floating platform model previously designed by a capstone group in the 2020-2021 school year which will be retrofitted with motors to pull and release tensioned anchors on the sea floor. Project goals include increasing buoyancy and floatability of the model, designing supporting elements for the motor systems, and programming the electrical components to actively sense and correct the platform's tilt. Constraints include lead time on ordered parts and the weight that the components add to the platform. Regarding the mechanical components on the platform, there are constraints securing them to the model itself. We are proposing printing a 3D cover that matches the area on top of the platform and including connections/tie-downs for the motors and pulleys for the system. This would increase weight but allow easier modifications to occur. The last constraint is using electrical components near water. Most of the components will need to be waterproofed or at least water resistant.

The state of the art system is the Tension Leg Platform (TLP). This platform is the type that is being loosely modelled, the difference is that it is being made actively stabilized. A TLP works by submerging the buoyant platform underwater and tying tethers/ropes to the sea floor which hold it in position, which results in passive stabilization. The floating platform has excess buoyancy and is vertically moored by tensioned tendons (or tethers) which restrains vertical and rotational motions such as pitch and roll (Chakrabarti et al., 2005). Horizonal motions are

allowed through swaying. Our project is similar to this system, but it involves pulling and releasing ropes/lines tied to the bottom of the sea floor from the platform deck. When a wave crashes into one side of the platform, a line will tighten on that side to counteract the motion of the wave, and later release. Other methods that were considered are the Spar-buoy and Semi-submersible methods.

To solve the problem, the 3D model will need to be studied to examine how it interacts with waves. Using a gyro sensor atop of the platform, BODE plots will be created which represent the frequency and amplitude response of the waves. This will allow us to find the model's limits when it comes to tipping and swaying caused by the ocean waves. This experimentation will occur in a large tub of water deep enough to house the 3D printed model with its connected ropes. The second part is programming through an Arduino to link the motion of the gyroscopic sensor to the pulling of the ropes. This will be in conjunction with the testing stage of the project, where modifications to code as well as the physical model will have to be made.

By the end of the project, the 3D model will be able to minimize rocking due to the artificially created. This would prove that it is possible to have efficient floating turbines in deep ocean water, thus unlocking more potential area for these large wind farms.

The Struggle over Offshore Wind Energy in Virginia

How have proponents and opponents of the Virginia Offshore Wind Project advanced their respective agendas?

Introduction

Is wind energy a viable source of energy for Virginia? Wing energy can serve a growing share of total energy demand. The Coastal Virginia Offshore Wind project (CVOW) off the coast of Virginia Beach is the newest development in green energy and is predicted to provide electricity to 650,000 homes by its completion. Two turbines have already been assembled with another 180 starting in 2024 (Dominion Energy, 2020). CVOW has substantial implications for Virginians.

Researchers have investigated social aspects of wind farming. Carstensen et al. (2006) found that the Nysted Wind Farm in Denmark harmed the local porpoise population. Hindmarsh (2014) attributed protests and lasting distrust of "big wind" in Australia to developers' failure to accommodate the populations affected. In a study of coal and wind energy in West Virginia, Collins et al. (2012) found that cumulative employment and earnings became higher when wind energy plus underground mining of coal was utilized as opposed to only coal mining.

Participants include manufacturers, trade associations, federal agencies, as well as residents of the area. Manufacturers include contractors and site developers. Dominion Energy (2020) is the leading developer of the CVOW project. Dominion is Virginia's principal electric power company. It aims to achieve net-zero greenhouse gas emissions by 2050, and CVOW project is part of this plan. Siemens Gamesa, a renewable energy company, will build the turbine blade facilities at the Portsmouth Marine Terminal, where the turbine equipment will be delivered (Siemens Gamesa, n.d.). Siemens Gamesa wind plants generate 100GW, enough power for 87 million homes (Siemens Gamesa, n.d.).

The Virginia Conservation Network (VCN) represents 150 advocacies committed to protecting Virginia's natural resources (VCN, n.d.). VCN demands that Dominion ensure that the CVOW project offers affordable power and employment opportunities (VCN, n.d.). The Sierra

Club is a national environmental advocacy. It supports CVOW, noting that it may support 14,000 jobs (Sierra Club, 2016). The Bureau of Ocean Energy Management (BOEM), an agency of the U.S. Department of the Interior, reviews and approves offshore energy projects. BOEM approved CVOW in 2013 (BOEM, n.d.).

Residents of nearby Hampton Roads and Virginia Beach are divided about CVOW. Ron Spangler, a Norfolk fisherman, told a reporter he had feared the project would reduce his catch. Following the installation of the first two turbines, however, fishing improved because the turbines offer fish artificial reefs. Spangler now supports CVOW. “It’s going to be unbelievable,” he said (WTKR, 2021).

References

BOEM (n.d.). Bureau of Ocean Energy Management. Coastal Virginia Offshore Wind Project (CVOW). https://www.boem.gov/renewable-energy/state-activities/coastal-virginia-offshore-wind-project-cvow

Carstensen, J., Henriksen, O. D., & Teilmann, J. (2006). *Impacts of offshore wind farm construction on harbour porpoises: Acoustic monitoring of echolocation activity using porpoise detectors (T-PODs). Marine Ecology Progress Series, 321, 295–308.*

CCES (2021, Oct. 27). Center for Climate and Energy Solutions. Renewable Energy. https://www.c2es.org/content/renewable-energy/

Chakrabarti, S., Halkyard, J., & Capanoglu, C. (2005). *Chapter 1—Historical Development of Offshore Structures. In S. K. Chakrabarti (Ed.), Handbook of Offshore Engineering (pp. 1–38). Elsevier.*

Collins, A. R., Hansen, E., & Hendryx, M. (2012). *Wind versus coal: Comparing the local economic impacts of energy resource development in Appalachia. Energy Policy, 50, 551–561.*

Dominion Energy. (2020, June 29). Dominion Energy Completes Construction of First Offshore Wind Project in U.S. Federal Waters—Jun 29, 2020. https://news.dominionenergy.com/2020-06-29-Dominion-Energy-Completes-Construction-of-First-Offshore-Wind-Project-in-U-S-Federal-Waters

Hindmarsh, R. (2014). *Hot air ablowin! "Mediaspeak", Social Conflict, and the Australian "decoupled" wind farm controversy. Social Studies of Science, 44(2), 194–217.*

Siemens Gamesa. (n.d.). Global leadership grows: Siemens Gamesa solidifies offshore presence in U.S. with Virginia blade facility. https://www.siemensgamesa.com/en-int/newsroom/2021/10/offshore-blade-facility-virginia-usa

Sierra Club. (n.d.). (2016, September 22). Offshore Wind. https://www.sierraclub.org/virginia/offshore-wind

VCN (n.d.). Virginia Conservation Network. Our 2022 Common Agenda—VCN Environmental Briefing Book. Virginia Conservation Network. Retrieved October 31, 2021, from https://vcnva.org/our-common-agenda/

WTKR. (2021, Aug. 20). How the Coastal Virginia Offshore Wind Project is affecting marine life. https://www.wtkr.com/news/how-the-coastal-virginia-offshore-wind-project-is-affecting-marine-life