Harnessing the Power of the Seas When Generating Sustainable Wind Power
(Technical Topic)

How the U.S. Army Corps of Engineers is Changing the Culture Surrounding Environment Conservation
(STS Topic)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree

Bachelor of Science, School of Engineering

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Fall, 2020

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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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Introduction

Wind turbines provide a source of clean, renewable energy; however, many people oppose their construction because they can be an eyesore; they are prone to killing birds, bats and other flying wildlife; and they require large open spaces in order to operate effectively, and clearing a large enough space can be harmful to the natural environment. Offshore wind turbines present an alternative, but they can be very dangerous, expensive, and complicated to construct since their base must be built beneath deep waters. Floating wind turbines offer a compromise – they take advantage of the high, steady wind conditions and open space in the ocean while being easy to safely build on land (*Globalizing floating wind*). While they have the potential to generate massive amounts of power and lack many of the drawbacks of traditional wind turbines, little research has evaluated their potential, and thus they are currently expensive to develop and build.

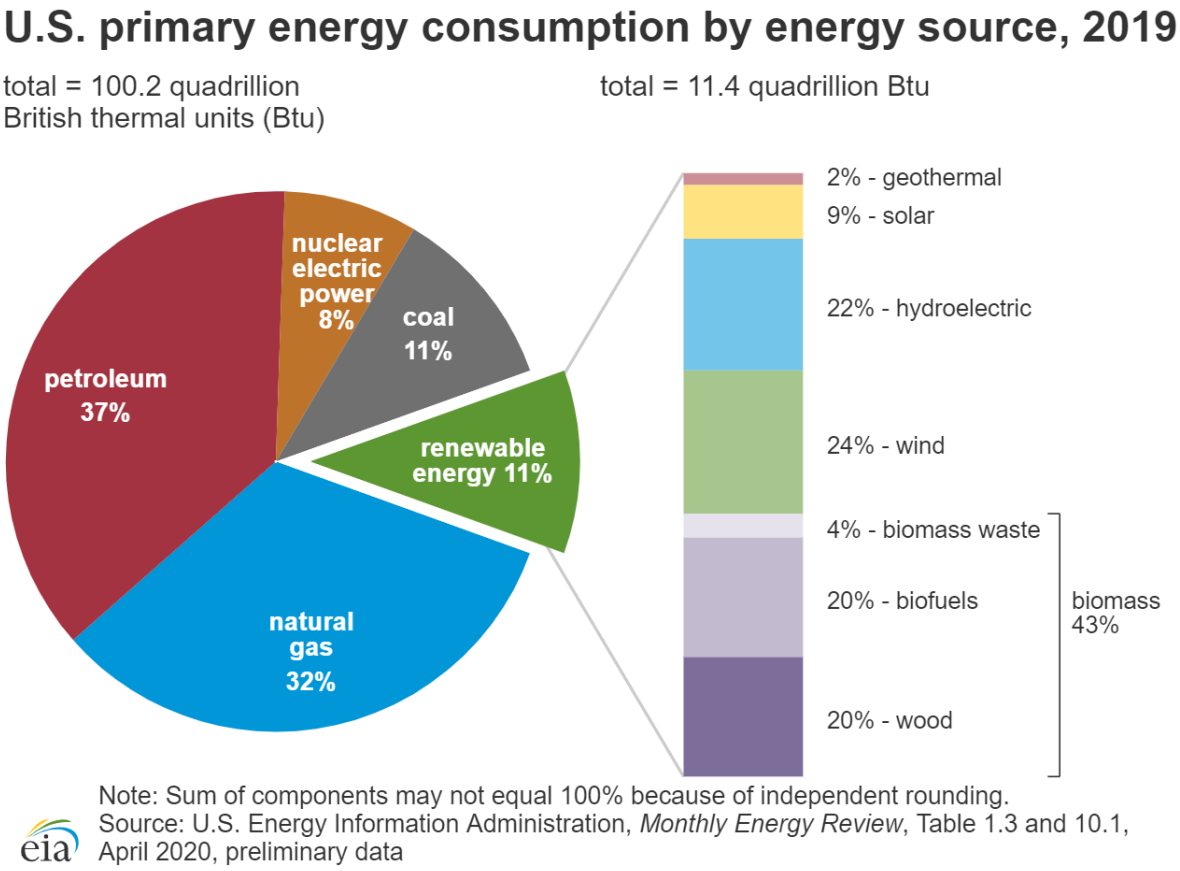
Profits are typically valued over the environment, and when given the chance, corporations will use the cheapest source of energy available. This means that the energy industry is stuck in a circular loop – time and money need to be invested in the renewable energy sector to make it cheaper and easier to produce, though corporations want to use the cheapest source of energy (typically nonrenewable fossil fuels), consequently money never gets invested in green energy. To break out of this loop, some outside source must force change. The U.S. Army Corps of Engineers (USACE) is hoping to drive this. USACE requires its contractors to change how they approach their construction plan by requiring all general contractors to submit an environmental protection plan (EPP) for government approval prior to beginning construction. This ensures that everyone on the project understands the expectations for how the environment must be protected during construction activities. USACE also requires all new buildings and

major renovations that began construction after fiscal year (FY) 13 to be LEED Silver Certified unless specified otherwise (*USACE Army LEED® v4 Implementation Guide*). This guarantees that contractors are building sustainable buildings that can be measured against a standard metric. In addition to changing environmental-related requirements on their project sites, USACE is working to build systems that generate renewable energy, such as wind turbines and solar, geothermal, and hydropower energy systems (*Hydropower Program*).

Technical Topic

Wind energy has been used since 5000 BCE when it was used to propel boats down the Nile River. However, today's modern use of wind turbines expanded beginning in the 1970s due to an oil shortage. This shortage drove people to invest in new ways to generate electricity, and wind turbines proliferated to meet the demand. Between 1990 and 2019, the U.S. increased its percentage of wind energy from 1% to 7.3% by offering incentives nationwide to those who used green sources of energy (*The History of Wind Energy*). However, there is still room for improvement. Currently, only 11% of U.S. energy is from a renewable source, and only 24% of

that renewable energy is from wind energy (*U.S. energy facts explained*). The table below from the U.S. Energy Information Administration shows this breakdown.



U.S. primary energy consumption by energy source, 2019. (2020). U.S. Energy Information Administration (EIA). https://www.eia.gov/energyexplained/us-energy-facts/.

While it may seem that more wind turbines need to be constructed, the solution is more complicated. Many people oppose the construction of more wind turbines. They can be unsightly, threatening to the surrounding wildlife population, exhibit inconsistent results, and require deforestation for their construction (Lloyd).

However, there is a plentiful resource that is currently overlooked – the ocean. It is a vast area that has high, consistent winds, is not within eyesight of the population, would be much less disruptive to bird populations, and would not require large amounts of trees to be cleared.

Offshore wind turbines have been built in the past, and they have been relatively successful. However, they are expensive and dangerous to build since their base needs to be drilled deep into the ground, fifty or more meters beneath rough waters (*What are the advantages and disadvantages of offshore wind farms?*). Many companies seeking to build an energy-producing system in the sea thus opt to simply build more oil rigs since they require the same amount of time, money, and effort to build and produce more electricity. However, this is not environmentally sustainable. My group maintains we have a viable solution – floating wind turbines.

Floating wind turbines have all the same advantages of traditional offshore wind turbines; however, they are much easier to construct since they do not need their base drilled into the earth's crust. Given enough money and research, floating wind turbines could be produced quickly and cheaply on land and then brought out to sea to be anchored. This would save a lot of time — it would be easier than trying to work over deep waters. It would also save a lot of money since traditional construction methods could be used to build the wind turbines on land, as opposed to requiring new construction methods to work on water.

I will be acting as the leader of a group consisting of five UVA mechanical engineering students, and we will test various designs of substructures for a floating wind turbine. We want to find a design that can withstand high winds and waves, is cost effective to construct and maintain, will be durable and not require extremely frequent maintenance, and is easy to transport from land (where it will be built) to sea (where it will be anchored). Our criteria to measure how well we achieve these goals is as follows:

1. Stability for high waves
    a. Ideal: 0 degrees tilt from normal

    b. Maximum: 10 degrees tilt from normal

2. Stability for high winds
    a. Ideal: can withstand 85 m/s winds
    b. Minimum: can withstand 40 m/s winds
3. Cost effectiveness
    a. Ideal: $57/MWh
    b. Maximum: $300/MWh
4. Durability
    a. Ideal: 20 year lifetime
    b. Minimum: 15 year lifetime
5. Portability
    a. Ideal: 1/6 of total turbine height beneath water when floating
    b. Maximum: 1/3 of total turbine height beneath water when floating

STS Topic

STS Introduction

In order for the U.S. to take steps towards implementing more green sources of energy, people and corporations must be willing to invest time and money into improving them. Unfortunately, most prefer cheap sources of energy on the market that can satisfy everyone's current needs. However, we are already seeing the repercussions of relying on these harmful sources of energy. Summers are getting hotter and longer while winters are getting milder and shorter, large storms and wildfires are becoming more frequent and severe, and the air and water is becoming more polluted (*The Rising Cost of Natural Hazards*). With the negative effects of

fossil fuels so clearly backed by science, it seems obvious that renewable sources of energy should be heavily researched and implemented.

However, there is nothing forcing a switch to renewable energy except environmental reasons. Natural gas and oil, while not renewable, are currently plentiful. The oil and gas industry employs 9.8 million Americans, and has large amounts of money and political influence (*How many jobs has the oil and gas industry created?*). This makes switching away from fossil fuels even more difficult. Prior to fossil fuels gaining popularity, Americans generated electricity by burning biomass (wood, charcoal, and coal). But a shortage of these resources forced them to find a new source of energy – oil and gas (Gross). Now that oil and gas are causing harm to the environment, a switch to renewable sources of energy (solar, wind, hydro, etc.) is needed. Unfortunately, scarcity of resources is not going to drive this transition. Neither will money, since natural gas and oil is more energy-dense than any other energy sources currently on the market. Instead, the government will need to drive this switch through legislation or strong incentives. The U.S. Army Corps of Engineers (USACE), is hoping to drive such change in the construction sector. They are requiring contractors to submit environmental protection plans (EPPs) prior to beginning construction on all projects; they are requiring their contractors to build according to LEED Silver guidelines; and they are working to implement solar, wind, hydroelectric, and geothermal energy systems in their projects. By making these requirements, they are ensuring that measures towards environmental protection are taken on military bases.

Background Documents

The U.S. Army Corps of Engineers must follow certain environmental regulations. ER 415-1-11 lays out the requirements for the biddability, constructability, operability,

environmental, and sustainability (BCOES) review. This review is required for all projects prior to advertisement to ensure the design, construction, and operation therein will follow all federal, state, and local environmental regulations. Additionally, the BCOES review ensures that the project will utilize the most modern energy performance optimization, sustainable materials, and water conservation techniques (*BIDDABILITY, CONSTRUCTABILITY, OPERABILITY, ENVIRONMENTAL AND SUSTAINABILITY (BCOES) REVIEWS*). ER 200-1-5 provides guidance concerning how environmental operating principles (EOP) for the project are implemented. The EOP outlines USACE's responsibilities in protecting the environment and its natural resources where it operates. It is intended that these practices become commonplace in daily life as they are enforced by the government (*POLICY FOR IMPLEMENTATION AND INTEGRATED APPLICATION OF THE U.S. ARMY CORPS OF ENGINEERS (USACE) ENVIRONMENTAL OPERATING PRINCIPLES (EOP) AND DOCTRINE*).

Framing Case Study

In a case study by Jeffrey Helpler, Catherine Neumann, and Annette Rossignol, the process for how USACE conducted an environmental evaluation on an old laboratory in Oregon revealed deficiencies that both broke environmental regulations and endangered the lives and environment around the facility (*Environmental Compliance and Ethics: A Case Study at a Facility of the US Army Corps of Engineers in Oregon*). The case study explains that the facility was eventually shut down, and it makes recommendations for how the government can prevent the construction of a similarly dangerous facility.

Scope of Analysis

My aim is to identify trends within USACE efforts to push for better environmental compliance on its job sites, using a combination of published case studies and interviews with

employees in the relevant branch at the Norfolk, VA district. USACE professes dedication to protecting the environment; however, I want to determine if they are actually accomplishing their goals, and, if so, how. When USACE is working on a job, they are typically thought of as the owner/stakeholder. Thus, the contractor must abide by the environmental regulations USACE puts forward.

However, the people who live in the area of the project can also be thought of as the stakeholder, since they must live with the lasting environmental impacts of the project both during and after project completion. Therefore, USACE has a responsibility to maintain a clean and healthy environment for affected citizens when they are planning, building, and maintaining a project. Regrettably, protecting the environment has become a controversial, partisan activity, which further increases the difficulty of enforcing environmental regulations and, especially, passing further protections to adapt to shifting standards. For USACE to be an effective protector of the environment, clear policies must be followed, lest it convey an indifferent attitude.

Next Steps

Short-Term Steps

- Speak to people at my internship about how they use environmentally friendly thinking in their day-to-day activities at work
- Work with my technical research group on refining our substructure design on our wind turbine

Medium-Term Steps

- Create a prototype of our wind turbine substructure design and perform testing on the various designs and see which one is closest in achieving our goals
- Work on STS research and finding more case studies to demonstrate my topic and add validity to my thesis.

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