Catch the Wave

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Abstract

According to the U.S. Department of Energy (U.S. DOE), at any given moment there is enough energy in the oceans' waves around the world to provide up to 2 trillion watts (W) of electricity! Wave energy is renewable and sustainable clean energy and oceans are an endless source of waves. The northeastern and western coasts of the United States are good locations to extract wave energy. This energy can be captured and stored in electrical capacitors and will provide a continuous supply of energy even on a calm day. Automating the selection of a site and using data over a longer period of time will result in a better site selection process compared to picking the sites randomly. Since there's a direct correlation between wind speed and wavelength, the wind speed is being used for the decision making. Historical data is available on the NOAA website. The CO-OPS API was used for Data Retrieval and marked the locations on the map with the speed and station information. Took the average of the wind speed data collected from Ocean buoys and available on the National Oceanic and Atmospheric Administrator's (NOAA) page. The data is collected at each station at 6-minute intervals over a 10-day period for all stations in the United States and sorted the averages in descending order. 5 sites with the highest wind speed averages along the coasts of the United States are selected to build either an onshore or an offshore wave energy power system.

Keywords:

## Introduction

The goal is to determine the top 5 sites along the coasts of the United States to build either an onshore or an offshore wave energy power system by using and evaluating the data collected from tides and currents.

According to the U.S. Department of Energy (U.S. DOE), at any given moment there is enough energy in the oceans' waves around the world to provide up to 2 trillion watts (W) of electricity! The data collected will determine how much reusable energy can be produced from the waves. Wave energy is renewable and sustainable clean energy and oceans are an endless source of waves. The northeastern and western coasts of the United States are good locations to extract wave energy. This energy can be captured and stored in electrical capacitors and will provide a continuous supply of energy even on a calm day. Automating the selection of a site and using data over a longer period of time will result in a better site selection process compared to copying and pasting the data into Excel for the sites picked randomly. The reason waves are a good energy source is because harnessing it doesn't emit any harmful gasses. The energy is also renewable making it a valuable source of energy.

What is the wave's length? The wave's length is the distance from one crest to another, or from one trough to another, of a wave. Two physical characteristics of a wave are amplitude and wavelength. The amplitude of a wave is the height of a wave as measured from the highest point on the wave, the peak or crest, to the lowest point on the wave, the trough. Wavelength refers to the length of a wave from one peak to the next.

What are fossil fuels? They are any of a class of hydrocarbon-containing materials of biological origin that occur within Earth's crust and can be used as a source of energy. Fossil fuels include coal, petroleum, natural gas, oil shales, bitumens, tar sands, and heavy oils. When

fossil fuels are burned, they release large amounts of carbon dioxide (greenhouse gas) into the air. The greenhouse gases get trapped in the atmosphere, which causes global warming.

Are there any economic benefits? Yes, there are. It is a low-cost energy source. There is a great abundance of water that is undrinkable and isn't being used as any other resources properly. Therefore, hydro energy would be a cheap way of getting energy and non detrimental to the Earth.

Since there is a direct correlation between wind speed and wavelength, the wind speed is used for my decision making. Historical data is available on the NOAA website. The CO-OPS API was used For Data Retrieval and marked the locations on the map with the speed and station information.

## Methodology

First, collect ocean buoy data from the National Oceanic and Atmospheric Administrator's (NOAA) page. This website has ocean buoy data from around the world. Limited the research to the United States only. Remove the spaces between paragraphs

Second, the data needed is not available at every station. First find out which stations capture wind speed data. Investigate the different buoys and find out which buoys have the wind speed information. There is a direct correlation between wind speed and wave height according to NASA's education site. Some buoys have recent data and some have historical data. Investigate the maps and information on the NOAA page to better understand the data.

Third, manual collection of data, copying and pasting it to Excel for random sites that were selected will give only comparison for those sites based on limited information. For this project, the data collection was automated by using the api.

Fourth, the stations that collect data capture wind speed every 6 minutes throughout the day. The project utilizes data from ocean buoys that automatically capture wind speed data every 6 minutes.

Fifth, CO-OPS API For Data Retrieval located at https://tidesandcurrents.noaa.gov/api/ for tides and currents.

Sixth, write a short program to collect an average 10 days' worth of data for each station in the United States that collects the wind speed information and write the station id, name and average wind speed in an Excel worksheet. Manual collection is less accurate and more time consuming.

Seventh, sort the data in the Excel worksheet from highest average to lowest.

Eighth, select the top 5 locations and the averages and plot it on a chart to compare the data visually.

Ninth, mark the locations on the map using the info window on each marker to show the data which includes the speed and station information.

Tenth, select the best site for an on or off shore power plant using the wave energy using the highest average wind speed.

Note: Since there is a direct correlation between wind speed and wavelength, the wind speed is being used for the decision making. Historical data is available on the NOAA website.

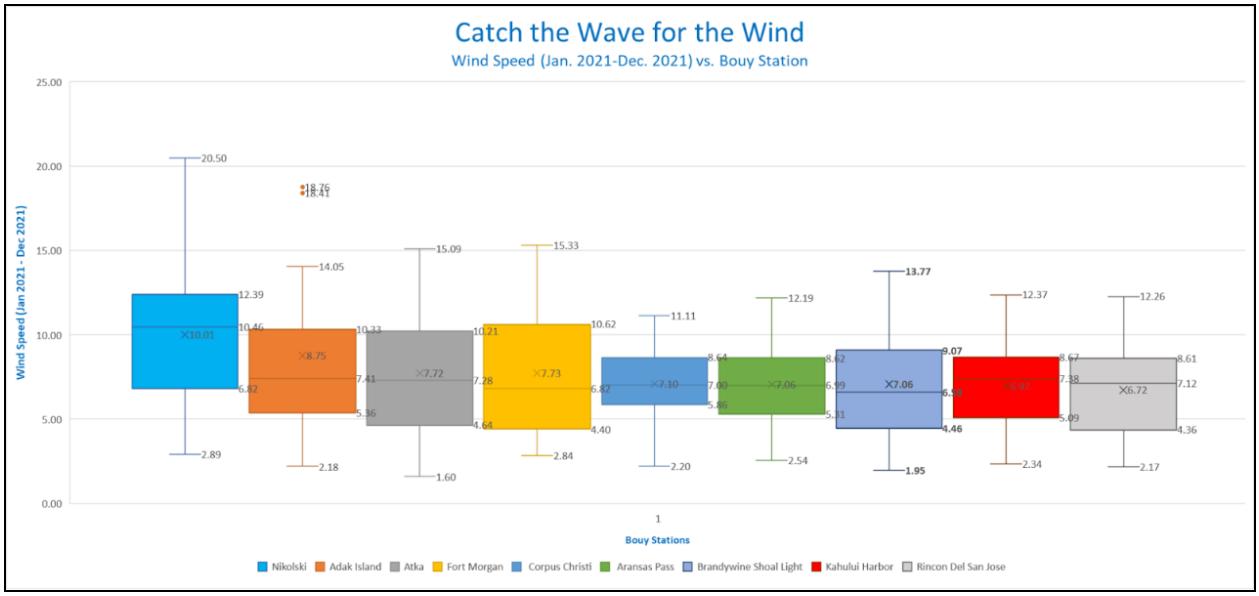
The program can be modified to change the number of sites selected and duration of the data collected.

I took the average of the data collected at each station at 6-minute intervals over a 10 day period for all stations in the United States where wind speed is collected. For this science

experiment, I collected data for 10 days for each station and averaged the data collected for each station. This information station id, station name, average of the 10-day data for that station is written in Excel for all US locations where wind speed is available. The averages were sorted in descending order and then picked the top 5 stations that have the highest wind speed averages over the 10 day period as the best locations to build a power plant. The program can be changed to gather data for a longer period of time, even a year to make a better decision. There is historical data available for those stations from NOAA.

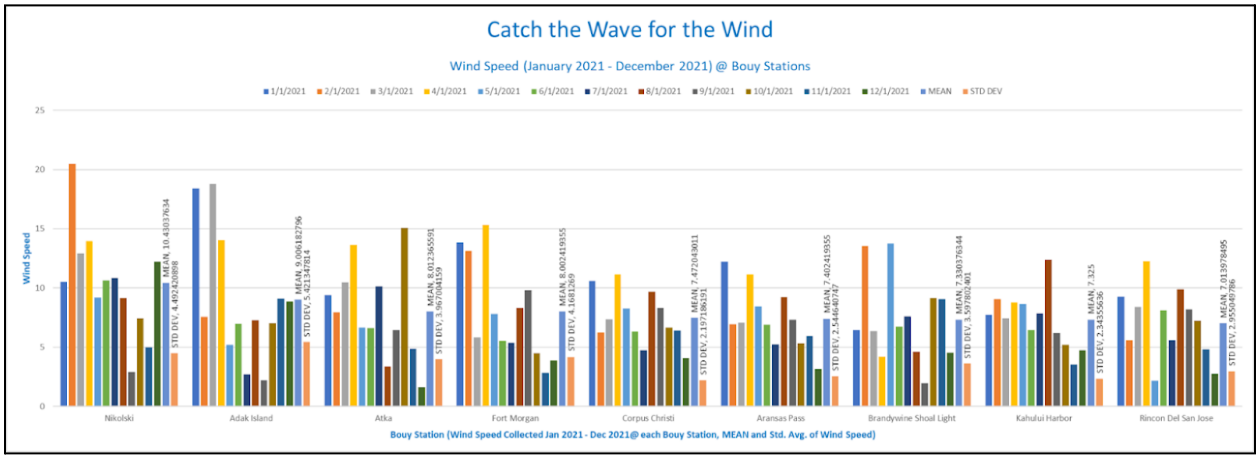
## Data and Results

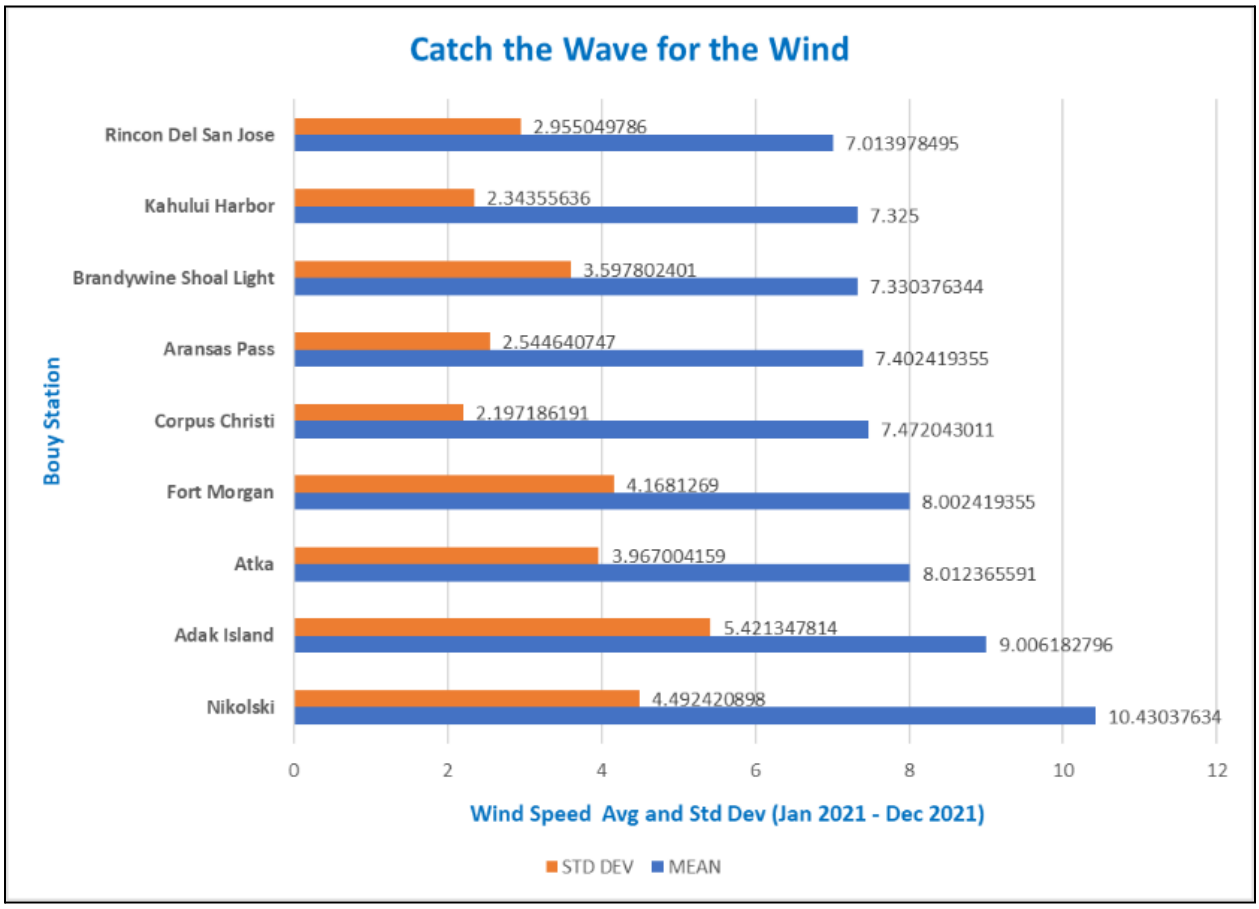
| | | | | **BOUY STATIONS** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nikolski | Adak Island | Atka | Fort Morgan | Corpus Christi | Aransas Pass | Brandywine Shoal Light | Kahului Harbor | Rincon Del San Jose |
| **1/1/2021** | 10.5 | 18.41 | 9.39 | 13.83 | 10.61 | 12.19 | 6.44 | 7.73 | 9.26 |
| **2/1/2021** | 20.5 | 7.55 | 7.93 | 13.11 | 6.24 | 6.94 | 13.55 | 9.04 | 5.56 |
| **3/1/2021** | 12.93 | 18.76 | 10.45 | 5.83 | 7.36 | 7.05 | 6.37 | 7.43 | 8.39 |
| **4/1/2021** | 13.95 | 14.05 | 13.64 | 15.33 | 11.11 | 11.15 | 4.19 | 8.75 | 12.26 |
| **5/1/2021** | 9.17 | 5.19 | 6.64 | 7.81 | 8.25 | 8.42 | 13.77 | 8.64 | 2.17 |
| **6/1/2021** | 10.63 | 6.98 | 6.58 | 5.51 | 6.32 | 6.89 | 6.73 | 6.42 | 8.09 |
| **7/1/2021** | 10.82 | 2.68 | 10.13 | 5.37 | 4.72 | 5.25 | 7.59 | 7.86 | 5.56 |
| **8/1/2021** | 9.13 | 7.27 | 3.37 | 8.29 | 9.66 | 9.24 | 4.63 | 12.37 | 9.87 |
| **9/1/2021** | 2.89 | 2.18 | 6.45 | 9.78 | 8.3 | 7.3 | 1.95 | 6.18 | 8.2 |
| **10/1/2021** | 7.43 | 7.04 | 15.09 | 4.48 | 6.65 | 5.33 | 9.15 | 5.2 | 7.23 |
| **11/1/2021** | 4.99 | 9.08 | 4.86 | 2.84 | 6.39 | 5.94 | 9.05 | 3.52 | 4.83 |
| **12/1/2021** | 12.21 | 8.87 | 1.6 | 3.86 | 4.06 | 3.14 | 4.55 | 4.74 | 2.74 |




| Buoy Station | 1/1/2021 | 2/1/2021 | 3/1/2021 | 4/1/2021 | 5/1/2021 | 6/1/2021 | 7/1/2021 | 8/1/2021 | 9/1/2021 | 10/1/2021 | 11/1/2021 | 12/1/2021 | MEAN | STD DEV | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nikolski | 10.49677419 | 20.49677419 | 12.93225806 | 13.95483871 | 9.174193548 | 10.62903226 | 10.82258065 | 9.129032258 | 2.893548387 | 7.432258065 | 4.993548387 | 12.20967742 | 10.43038 | 4.492421 | |
| Adak Island | 18.41290323 | 7.54516129 | 18.76129032 | 14.0516129 | 5.193548387 | 6.980645161 | 2.683870968 | 7.270967742 | 2.183870968 | 7.038709677 | 9.083870968 | 8.867741935 | 9.006183 | 5.421348 | |
| Atka | 9.393548387 | 7.932258065 | 10.4483871 | 13.64193548 | 6.635483871 | 6.583870968 | 10.13225806 | 3.367741935 | 6.451612903 | 15.09354839 | 4.864516129 | 1.603225806 | 8.012366 | 3.967004 | 5.989685 |
| Fort Morgan | 13.82580645 | 13.11290323 | 5.829032258 | 15.32580645 | 7.812903226 | 5.509677419 | 5.367741935 | 8.287096774 | 9.783870968 | 4.480645161 | 2.835483871 | 3.858064516 | 8.002419 | 4.168127 | |
| Corpus Christi | 10.60645161 | 6.235483871 | 7.361290323 | 11.11290323 | 8.245161290 | 6.319354839 | 4.722580645 | 9.664516129 | 8.3 | 6.648387097 | 6.390322581 | 4.058064516 | 7.472043 | 2.197186 | |
| Aransas Pass | 12.19354839 | 6.935483871 | 7.045161290 | 11.14838710 | 8.416129032 | 6.893548387 | 5.251612903 | 9.235483871 | 7.3 | 5.329032258 | 5.941935484 | 3.138709677 | 7.402419 | 2.544641 | |
| Brandywine Shoal Light | 6.438709677 | 13.55161290 | 6.370967742 | 4.193548387 | 13.76774194 | 6.725806452 | 7.590322581 | 4.629032258 | 1.951612903 | 9.151612903 | 9.048387097 | 4.545161290 | 7.330376 | 3.597802 | |
| Kahului Harbor | 7.729032258 | 9.041935484 | 7.432258065 | 8.748387097 | 8.638709677 | 6.419354839 | 7.864516129 | 12.37419355 | 6.183870968 | 5.203225806 | 3.522580645 | 4.741935484 | 7.325 | 2.343556 | 4.834278 |
| Rincon Del San Jose | 9.261290323 | 5.564516129 | 8.387096774 | 12.26451613 | 2.167741935 | 8.093548387 | 5.558064516 | 9.874193548 | 8.196774194 | 7.232258065 | 4.829032258 | 2.738709677 | 7.013978 | 2.955055 | |

The stations with an average wind speed of more than 7m/s were compared. The mean and standard deviation were both taken into account in order to make the decision. There were two stations that were chosen to have the best wind speed mean and standard deviation, they were Atka and Kahului Harbor. Both had a high average wind speed and a low standard deviation.



## Conclusion

The purpose of this experiment was to find the best place in America to set up a renewable energy source for power/electricity using wind speed data that was collected from ocean buoys. The Major findings from collecting the data is that the wind speeds are not always consistent. Them not being consistent for all the stations made me change my decision on where the best place would be, since for a power plant, you would want reliability along with high wind speeds. The most favorable sites would be Atka and Kahului Harbor. I chose these two since they both have high means and lower standard deviations than the other stations that I picked to be in the top 9. Other researchers, including the NDBC, state the wind speed and direction. The data collected by me shows the wind speed with more accurate numbers since the data was used from the buoy stations that were set up. Other researchers do make a clear point that the areas that the wind is being used from should have smooth surfaces and little to no friction in order to have faster wind speed. https://www.ndbc.noaa.gov/wstat.shtml & https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php#:~:text=Favorable%20sites%20include%20the%20 tops,elevations%20 above%20the%20 earth's%20 surface. The winds blow faster over the ocean than over the land since there is not as much friction over the water. This means that it is best to collect wind speed in coastal areas in the ocean. There should be more buoys set up on the coasts of the U.S. in order to be able to pinpoint good spots to put a renewable energy plant. More buoys in the same places would help to collect more accurate data and to see the consistency of the wind.

References

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