Preliminary Site Design

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1. Introduction

For the first part of the project development contest, we have a complete analysis of the selected area within Galveston Texas. The analysis includes the selection of three blocks out of a total of 90 blocks, keeping in mind multiple factors that could affect the creation of the wind farm. To accomplish this selection, a compilation of data was necessary that includes transit counts in 2020, aids to navigation, anchorage areas, ocean wave potential, oil and natural gas wells, shipping lanes and regulations, tropical cyclone storm segments, wrecks and obstructions, bathymetry, wind resources, environmental factors, and a transmission plan.

2. Site Selection

The coordinates from the lease blocks were obtained using QGIS [1]. Then Global Wind Atlas [2] was used to obtain wind speed and bathymetry data. The Marine Cadastre National Viewer [3] was used to obtain the data regarding the use of blocks.

2.1. Environmental Factors

One of the most important considerations for shareholders is the environmental impact of the wind farms. For this reason, we started discarding blocks that didn't comply. After analyzing the collected data, we reached to the conclusion that none of the 90 blocks represents a risk to the environment, protected species, corals in the area, among others.

2.2. Bathymetry

Figure 1, shows and bathymetry map of the zone containing the 90 lease blocks. The depth in the area is approximately $-14m$. Some parts are marked as $-17m$, $-16m$, but the average is $-14m$. These differences in depth are not a significant factor when selecting one of the 90 blocks since the depths are similar. The depths at the area are classified as shallow waters, enabling the installation of turbines with fixed bottom. The best structure for this area is the Jacket as the soil is soft and they are proven effective from the oil and gas industry [4].

2.3. Wind Resources

The winds in the area for a height of 100 m are approximately $7.4\ m/s$. Figure 2 shows a Wind Resource Map. As the distribution of the wind between the 90 blocks is very similar, we can say that the wind resource does not represent a significant factor when selecting one of these.

2.4. Anchorage Areas

An anchorage area is a place where boats and ships can safely drop anchor. Figure 3 shows a map of anchorage areas in the zone. With this we were able to discard the first three consecutive frames down in the zone since locating turbines in these areas could mean a risk for the boats that anchor in that area.

2.5. Aids to Navigation

Structures intended to assist a navigator to determine position or safe course, or to warn of dangers or obstructions to navigation. This dataset includes lights, signals, buoys, day beacons, and other aids to navigation. After analyzing the data, 5 additional blocks were discarded within the zone since they present obstructions when locating the turbines.

2.6. Waves Potential

Data shows that vast majority of the 90 blocks have a wave potential of less than 20 m. However, some blocks to the south have a swell between 0.0 and 3.2 kW/m. However, none of the possible values among the margins mentioned present any impediment when installing turbines in one of these blocks.

2.7. Oil and Natural Gas Wells

Oil and Natural Gas wells are surface boreholes drilled into the ocean floor within for purposes of mining. Figure 4 show us a map that represent the oil and natural gas wells. With this data collected, many of the blocks were discarded as they represent a risk for any construction.

2.8. Shipping Lanes and Regulations

Shipping zones delineate marine activities and regulations for marine vessel traffic. Figure 5 shows a map of shipping lanes and regulations of the area. The blocks that remain within the traffic lines or any delineation should be immediately discarded since these areas present continuous boat traffic.

2.9. Tropical Cyclone Storm Segments

The hurricane dataset is taken from the International Best Track Archive for Climate Stewardship (IBTrACS) data set. The passage of hurricanes through the area may be uncertain but the area is susceptible to those types of climate conditions. The possible hurricane paths and category data reflected that some blocks can be in the trajectories of the storms. However, most blocks will be impacted directly or indirectly by hurricanes and tropical storms, for that reason it is not a major factor to discard blocks.

2.10. Wrecks and Obstructions

Figure 6 shows us some of the wrecks registered in the area. These areas represent an obstruction when placing the turbines, for this reason each block that presents a wreck has been discarded.

2.11. Transmission Plan

Figure 7 represents electric power substations primarily associated with electric power transmission. These substations are considered facilities and equipment that switch, transform, or regulate electric power at transmission level voltages. The substations presented within the orange circle in Figure 7 are considered possible interconnection points for the transmission plan.

2.12. Final Block Selection

Considering everything previously analyzed, we were able to make a complete comparison of those things that prevented the use of any block. Figure 8 shows the three blocks selected for use. These do not present any impediment for the placement of turbines, nor do they represent a risk for navigators, fishermen, endangered species, protected areas, among others. Also, its position is brought closer to the possible power substation centers while complying with other considerations.

3. Turbine Selection

The Table 1 shows three wind turbine models for offshore applications taken from Furrow [5]. The Figure 9 shows the power curve for the Gamesa G132, it produces the most nominal power. Even tough, the nominal capacity of the Gamesa G132 is $5MW$, it requires a wind speed of $15\ m/s$ to achieve it. For $7.4\ m/s$ we expect about $2MW$ of generated power.

Turbine name	Manufacture	Offshore	Hub Height (m)	Diameter (m)	Blade Ratio (m)
Gamesa G128 5.0 MW Class IB Offshore	Gamesa	Yes	84 94	128	64
Gamesa G132 5.0 MW Class S Offshore	Gamesa	Yes	94	132	66
Vestas V66 2.0MW Class IA Offshore	Vestas Wind Systems A/S	Yes	60 78	66	33

Table 1. Turbine Selection

3.1. Number of Turbines per Lease Block

We are stipulating a separation distance of fifteen times the size of the rotor diameter between each turbine. Having in consideration this data we can install about nine turbines per lease block. We estimate that placing nine turbines per lease block would have a preliminary nominal capacity of $45MW$ per lease block. Therefore, the preliminary capacity of the farm of 27 turbines within the three selected blocks would be a $135MW$ wind farm. Figure 10 shows the separation of the turbines in one lease blocks. Each selected block would have a slightly different configuration after micrositing to ensure the turbines are not placed on an unsuitable area or cause wake losses to other turbines. On the other hand, the jacket has been chosen as the foundation to use as it is suitable for the soft soil in the Galveston and is proven by industry.

4. Conclusion

Due to the data collected regarding the assigned area, the most optimal perimeters were chosen for the installation of aerodynamic turbines. When choosing the perimeters, the different factors that could affect their proper functioning were considered, such as, for example, maritime transportation routes, shipwrecks, environmental factors, among others. The perimeters show a large area free of maritime transport routes and other factors such as marine life that may be affected, as well as a suitable surface for the installation of foundations and yet with a large source of wind.

5. Appendix A. Pictures

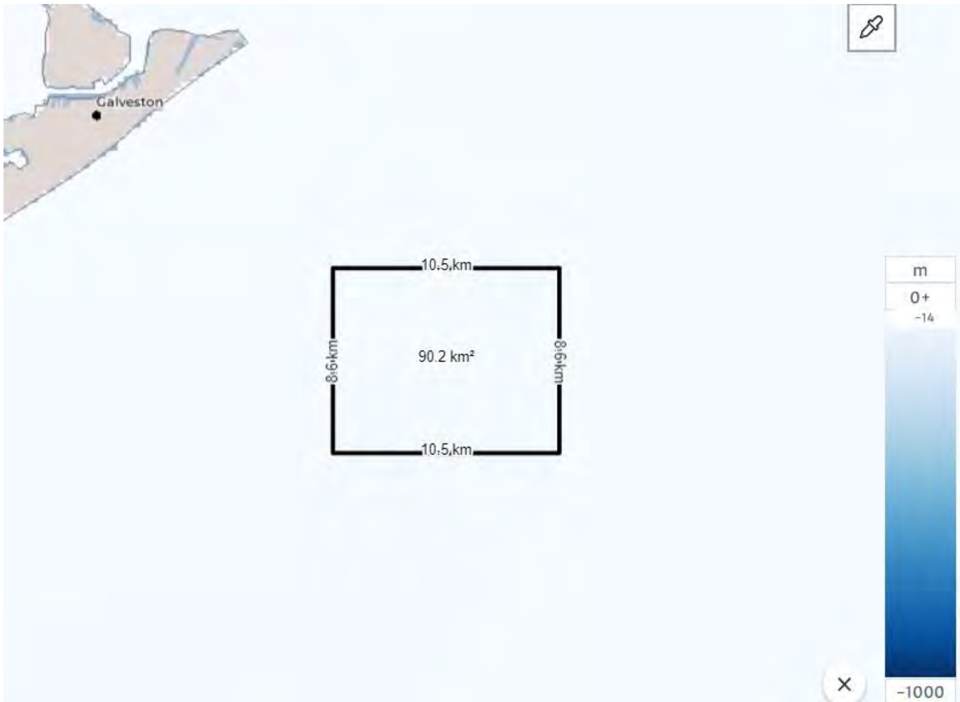

Figure 1. Bathymetry

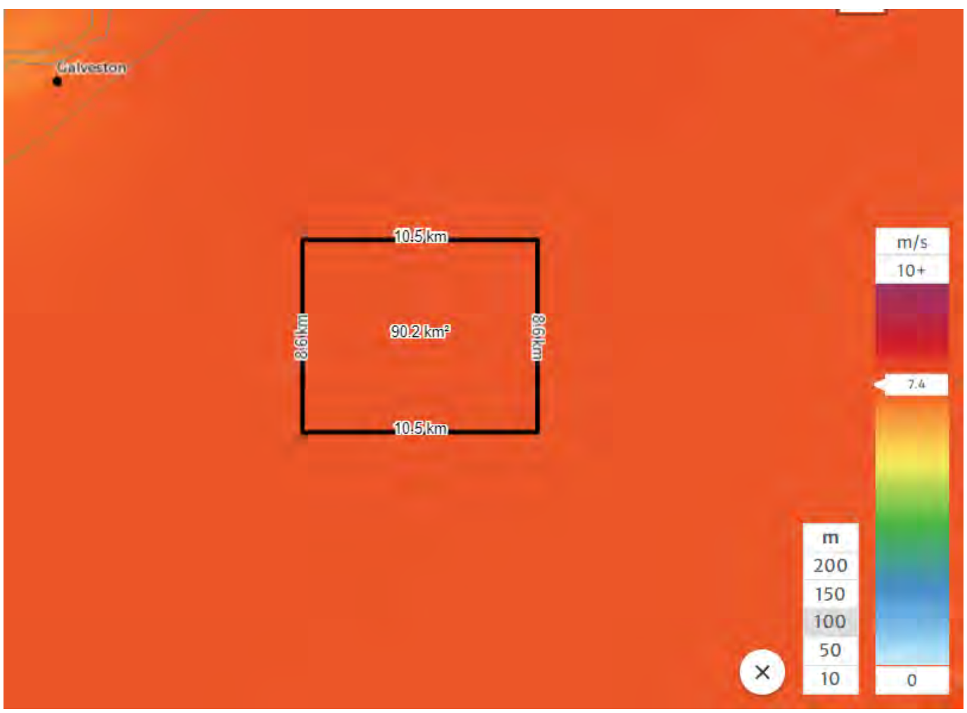

Figure 2. Wind Resources

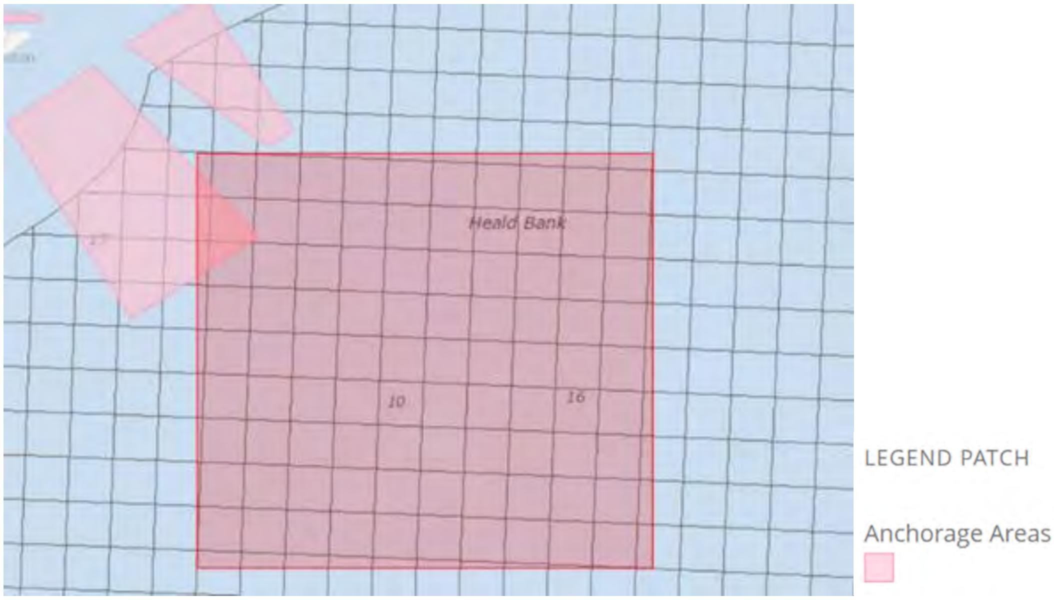

Figure 3. Anchorage Areas

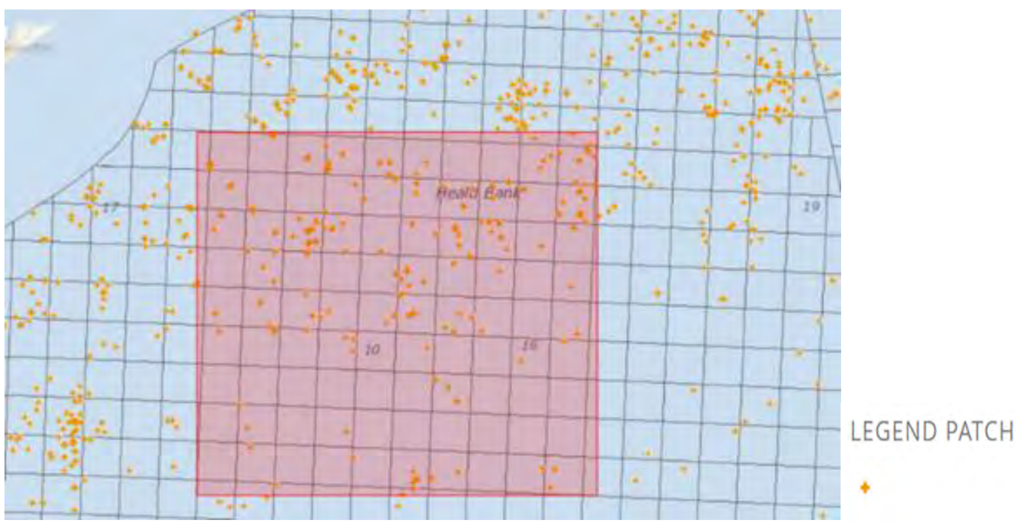

Figure 4. Oil and Natural Gas Wells

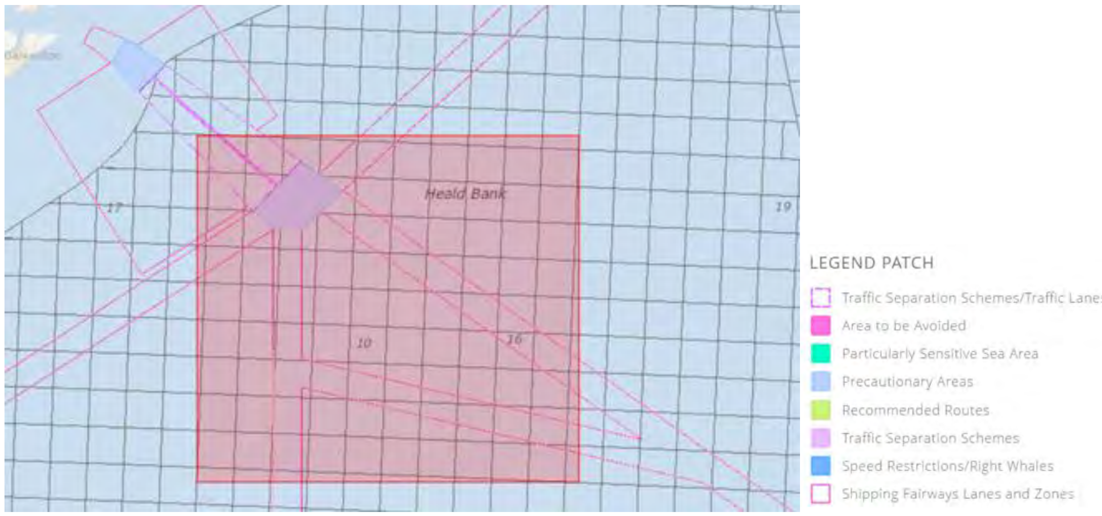

Figure 5. Shipping Lanes and Regulations

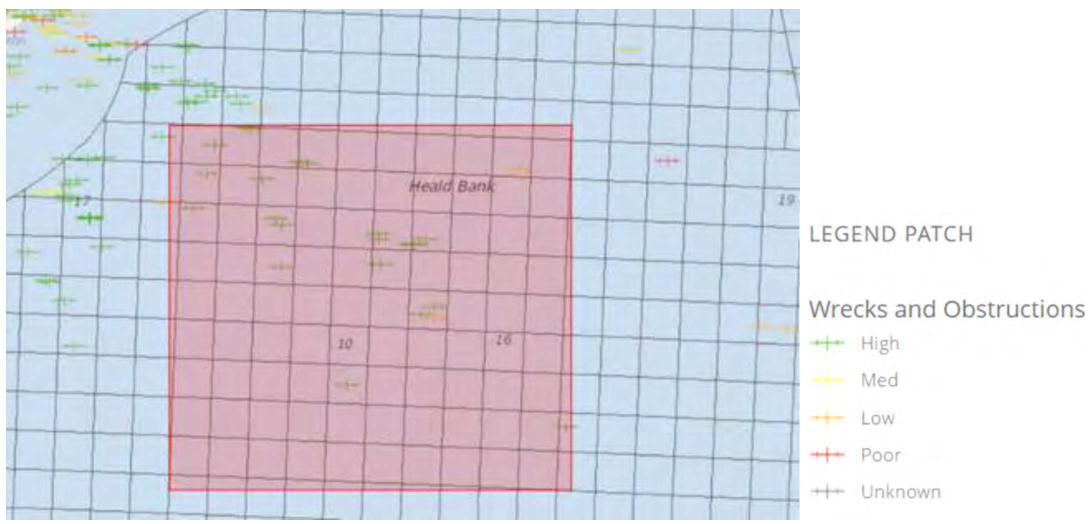

Figure 6. Wrecks and Obstructions

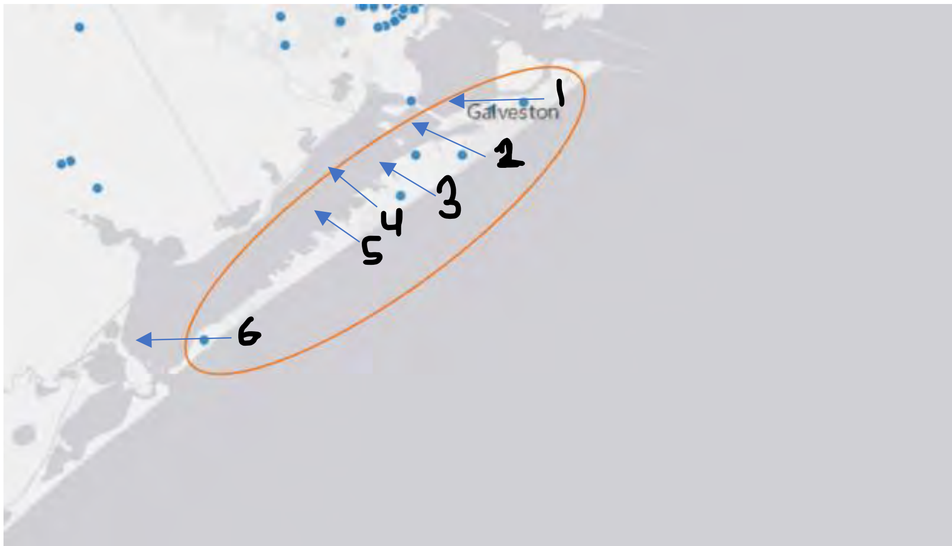

Figure 7. Electric Substations

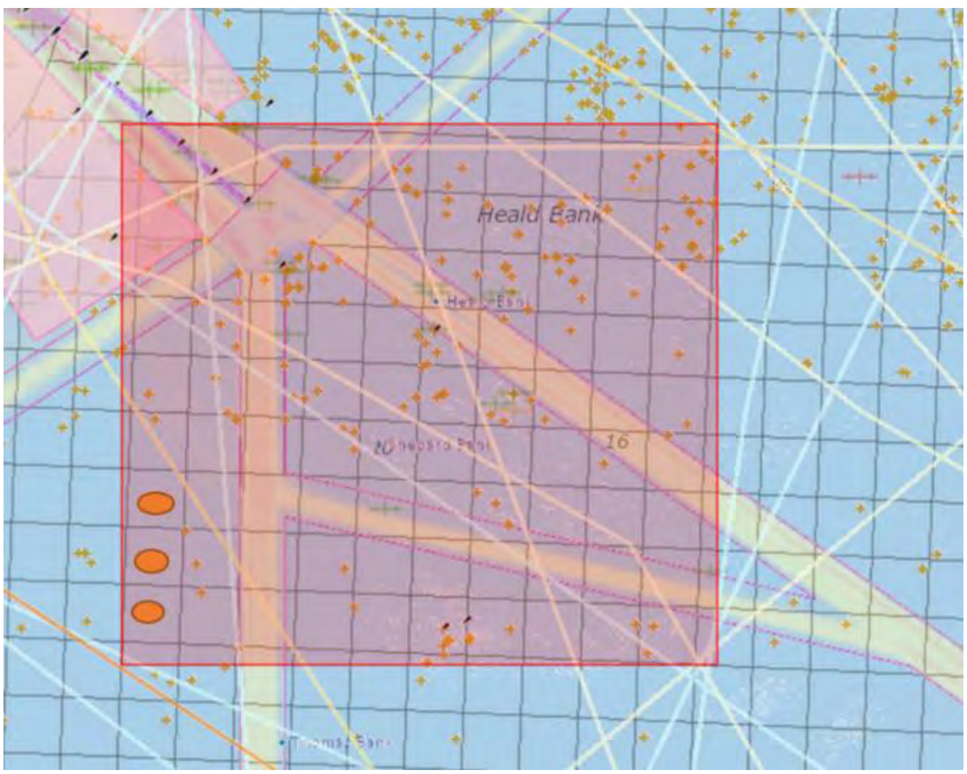

Figure 8. Final Block Selection

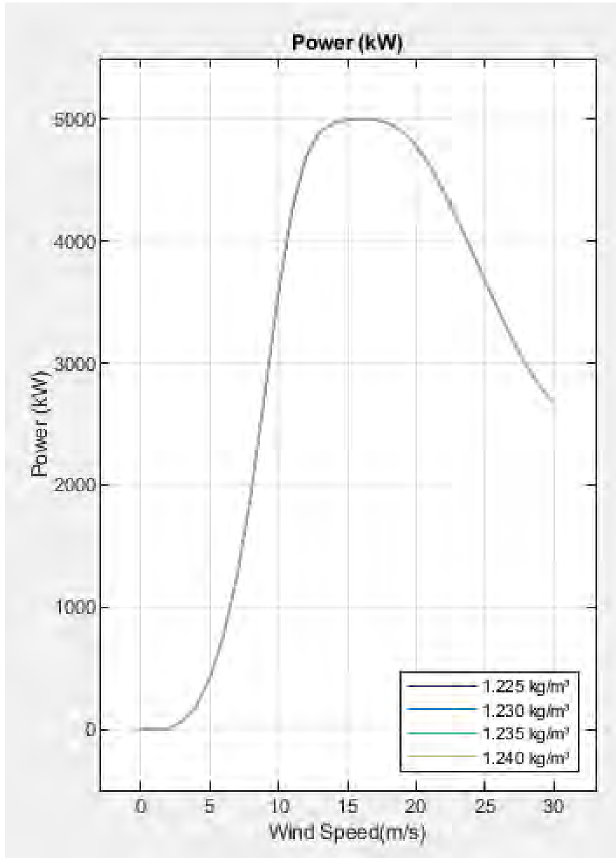

Figure 9. Gamesa G132 5.0 MW Class S Offshore power curve

Figure 10. Turbine site selection in one block

6. References

[1] QGIS Development Team, "QGIS Geographic Information System," 2021. [Online]. Available: https://qgis.org/en/site/.

[2] Technical University of Denmark, "Global Wind Atlas," 2021. [Online]. Available: https://globalwindatlas.info.

[3] Office for Coastal Management, "Marine Cadastre National Viewer," 2021. [Online]. Available: https://marinecadastre.gov/nationalviewer/.

[4] Bureau of Ocean Energy Management, "Offshore Wind in the US Gulf of Mexico: Regional Economic Modeling and Site- Specific Analyses," 2020. [Online]. Available: https://espis.boem.gov/final%20reports/BOEM_2020-018.pdf.

[5] "Furow," Solute, 2021. [Online]. Available: https://furow.es.