Project Report Topic: Wind Energy Resources

MAE 5010: Future Energy Systems

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Disclaimer: *Our project, being predominantly a data analysis and coding project, does not lend itself well to some of the aspects of more research- or literature-based projects. Our goal is to build a tool that simplifies the process of analyzing available wind data and producing useful, graphical outputs.*

1 Executive Summary

The state of New York has decided to develop GW of offshore wind energy by 2035. In order to invest in and integrate offshore wind generation into New York's power system, it is important to understand and characterize the available wind resources. This understanding and characterization is used to gauge the investment opportunity of using offshore wind generation to satisfy the load cycles of New York's power system.

In this project, the offshore wind resources at particular sites near the Long Island/New Jersey Shore are analyzed in Matlab for their diurnal and seasonal variabilities over a period of 5 years. The data is gathered from the NREL WIND Toolkit, where data on wind speed and extracted power is provided at 5-minute intervals over 5 years.

2 Direct Questions

2.1 Overview of existing onshore wind developments in New York State: determine their NYISO zone, their capacity, their annual output, and their annual and seasonal capacity factors

Due to the lack of available power output data, we used the aggregated data for wind output in three of New York's zones (this data was provided by Jeff Sward).

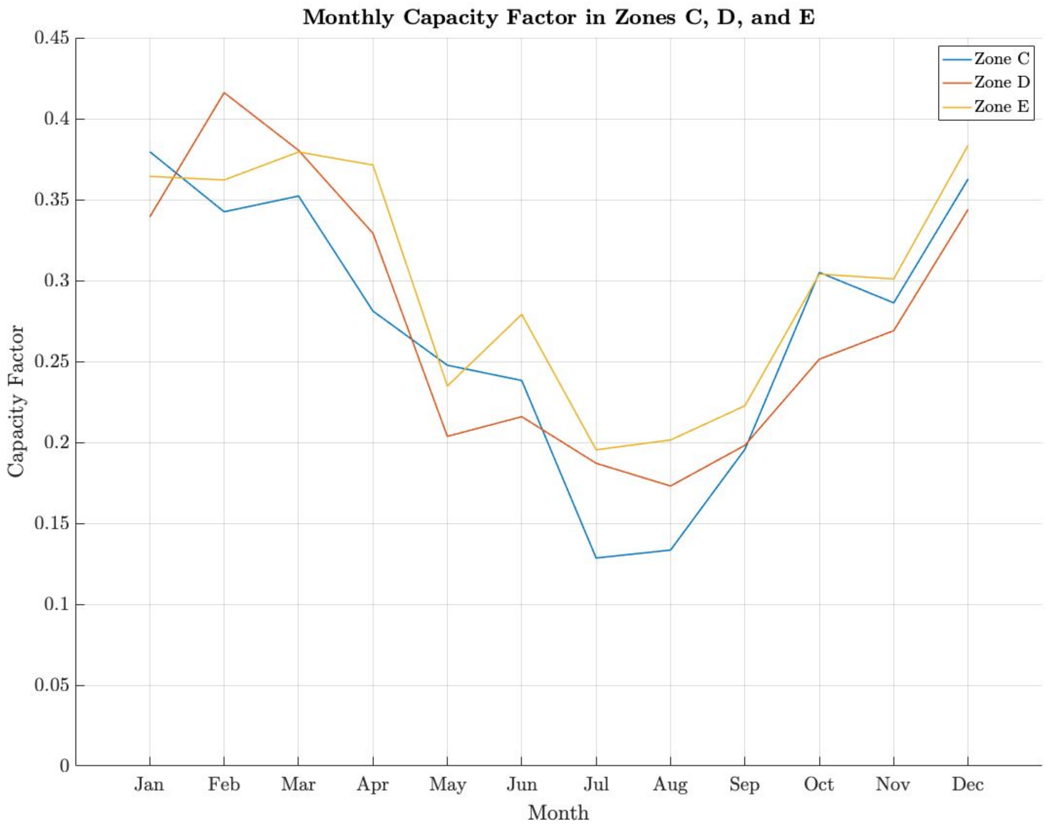

Figure 1: Monthly Capacity Factor Zones C, D, and E

2.2 Advantages and disadvantages of offshore wind energy

There are many advantages and disadvantages of offshore wind energy. The benefits are clear, offshore wind power benefits from increased wind speeds and less turbulent wind due to the unobstructed nature of the surface of the ocean. As a result, slightly increased wind speeds lead to a disproportionately large increase in power production potential. This is beneficial in maximizing the efficiency of wind farms thus decreasing the number of nacelles and space required. Additionally, many coastal regions are where highly populous cities with high energy demands are located thus electrical power transmission losses are lowered.

With that being said, there are also many disadvantages of offshore wind energy**.** The cost of installation and maintenance is one of the biggest obstacles, this is because it is very challenging to install seafloor mounted nacelles in water deeper than 60 m and servicing such farms would require special equipment. Furthermore, the designs of these wind farms would have to take into account the rough and corrosive nature of seawater. Finally, the sight of these wind farms off the coast could hurt tourism and decrease property values.

2.3 The current status of offshore wind development in New York State

According to the NYS Offshore Wind Master Plan, in 2019 Governor Cuomo proposed an expanded goal of 9,000 MW of offshore wind energy by 2035 as a major anchor in his efforts to decarbonize New York's electricity sector by 2040. A crucial component for achieving this goal by 2035 is the studies and surveys that support its development. Since the development of offshore wind should be done in a manner that is sensitive to environmental, maritime, social, and economic issues present, numerous studies have been completed by NYSERDA (New York State Energy Research and Development Authority) to contribute to a better understanding of the potential impacts and benefits of offshore wind energy development. The data provided to the public and developers by NYSERDA to date have ultimately reduced project risks and therefore reduced offshore wind costs to New York consumers. Some ongoing studies include an aerial baseline survey of marine wildlife which is intended to decrease the uncertainty of site development, reduce costs for offshore wind site developers, and minimize wildlife impacts by providing critical baseline data about wildlife distribution, abundance, and migratory patterns. So far NYSERDA has completed 20 studies supporting the development of offshore wind sites.

Currently, Governor Cuomo's PAUSE Executive Order and subsequent Executive Orders have resulted in NYSERDA pausing all on-site work conducted by contractors for clean energy programs through May 15.

3 Data Overview

Table 1: A typical data set from the wind prospector

Year	Month	Day	Hour	Minute	Power [MW]	Wind speed at 100 m [m/s]
2007	1	1	0	0	11.746	10.956
2007	1	1	0	5	11.787	10.974
...	...	...	...	...	...	...
2007	12	31	23	55	11.541	10.876

All the data used in this project is from The Wind Prospector, a database by the National Renewable Energy Laboratory. The wind data was averaged over 5-minute intervals throughout the entire year, resulting in over 105,000 data points. The data represented in this and the following section comes from Site_ID #70784 located at a latitude of -74 and a latitude of 40.

4 Diurnal Variability Calculations

We were able to calculate the diurnal variability of the power produced at each location. Using datasets from 2007 to 2012, we created a new data set, which we will call ***M***.

In ***M***, the power produced (at any given time on any given day) was equal to the average of the power produced at that time, on that day, between 2007 and 2012. Using ***M***, we were then able to calculate the average power produced at a given time across all 365 days of the year (that is, for example, we calculated the average power produced at 01:30 from January 1 to December 31, from 2007 to 2012). This data is represented in Figure 2.

The data used to produce Figure 2 was also used to produce Figure 3. However, instead of averaging the power produced at a given time over the entire year, we averaged it over each season.

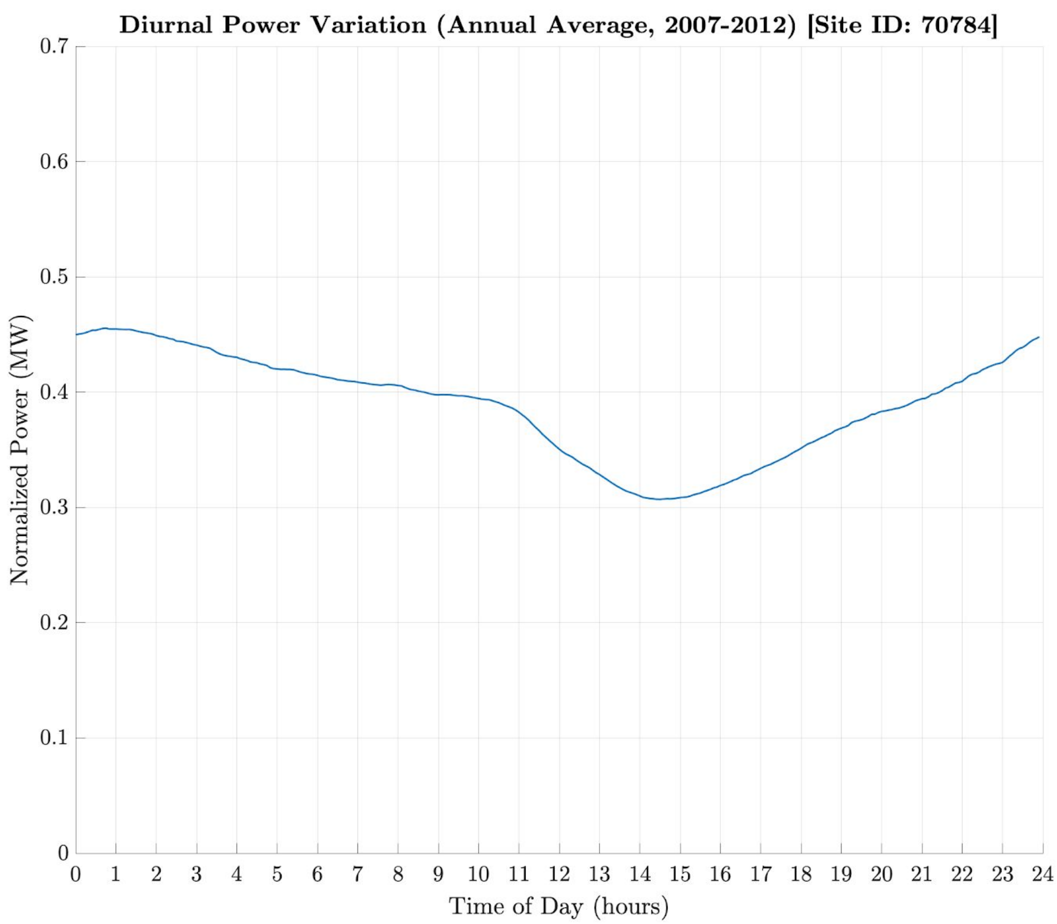

Figure 2: Diurnal Power Variation

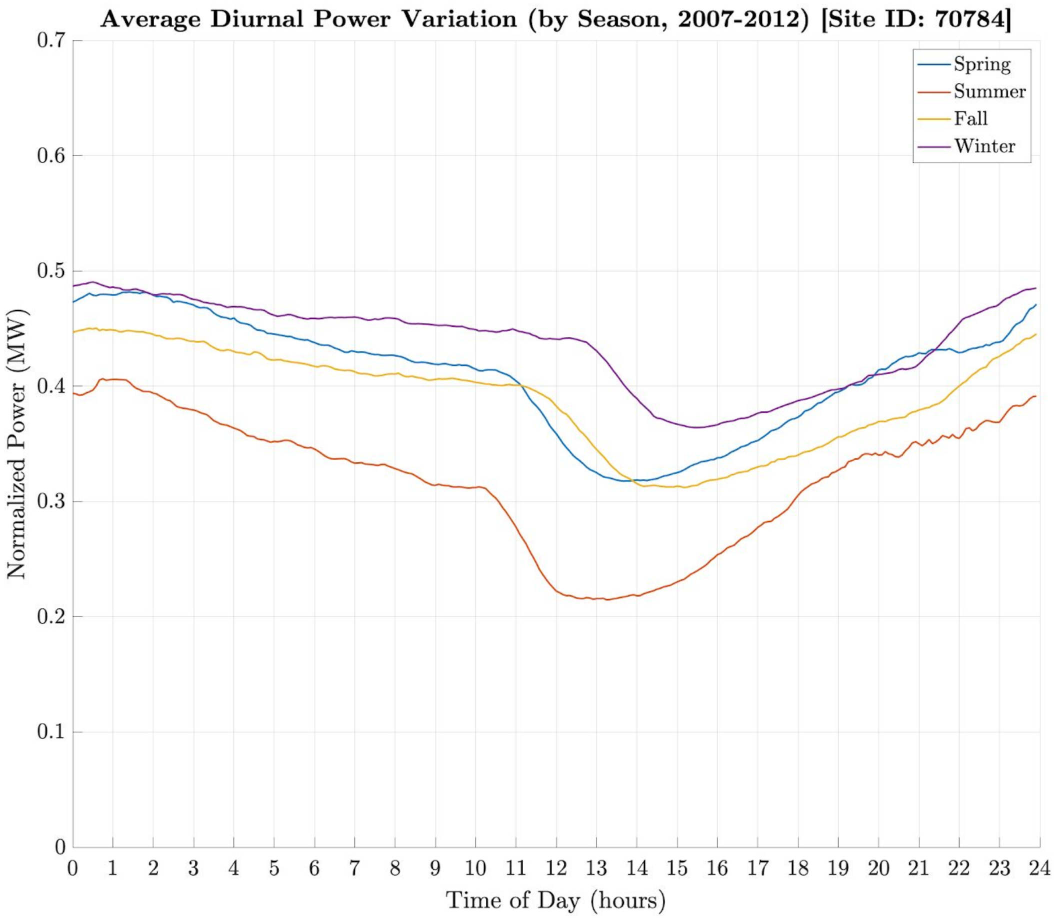

Figure 3: Average Diurnal Power Variation (by Season)

5 Daily Variability Calculations

Using ***M***, we were able to calculate the average power produced on a given day, from 2007 to 2012 (that is, for example, the average power produced on March 9, from 2007 to 2012. These average daily values were plotted for all 365 days of the year in Figure 4. This makes it easy for one to observe the annual trend in average daily power produced.

Figure 5, however, makes it easy for one to compare the average daily power produced by season (that is, one can easily compare how the average power produced on the 5th day of summer to the 5th day of winter).

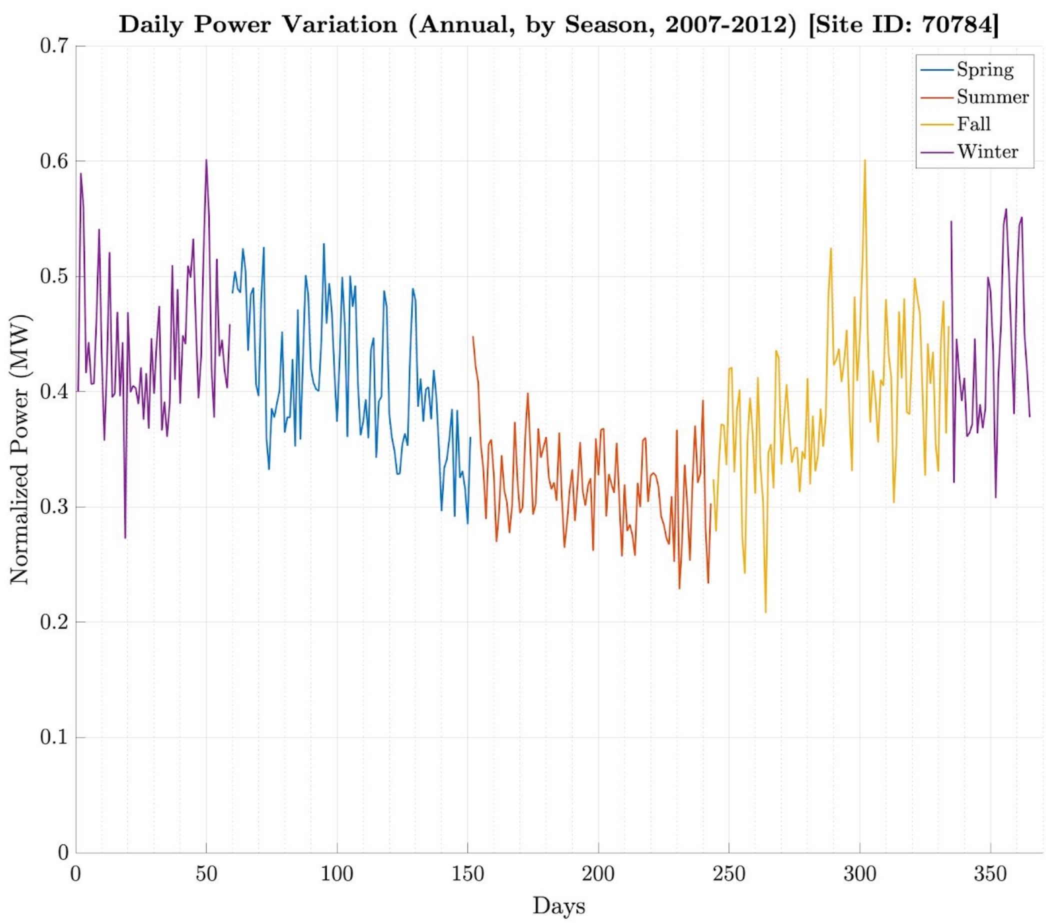

Figure 4: Daily Power Variation (Annual, by Season)

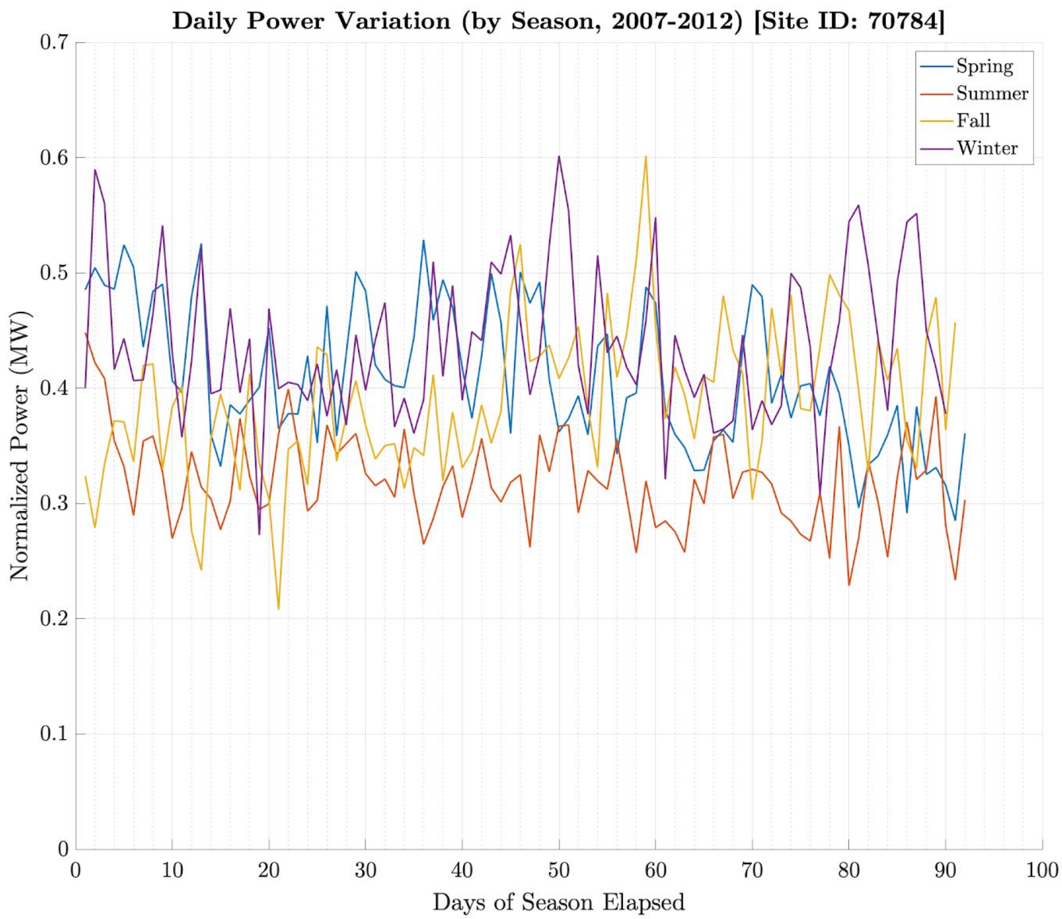

Figure 5: Daily Power Variation (by Season)

The figures in this draft report are for one site (site ID: 70784), but the code can be used for any site for which wind prospector datasets are available.

6 API

The WIND Toolkit API allows a configurable set of data in the form of a .csv to be downloaded from a national collection of wind stations. The Toolkit includes weather conditions and turbine power for more than 126,000 sites in the United States for the years 2007–2013. Data downloaded from the API can only be downloaded from a single point for a single year at a time.

In order to access the API, matlab launches the request URL that follows the format shown below:
GET /api/wind-toolkit/wind/wtk_download.*format?parameters*

The different requested parameters shown in Table 2 indicate the type of possible configuration for the request URL and what parameters are necessary.

Table 2: Request Parameters for API url

Parameter	Required	Value	Description
api_key	Yes	DEMO	Your developer API key.
wkt	Yes	Type: well-known text point string Default: None	A well-known text (WKT) representation of the geometry for which to extract data. May be a point or polygon geometry.
attributes	Yes	Type: comma delimited string array Default: None Options: *wind_speed, wind_direction, power, pressure, temperature, density*	Each specified attribute will be returned as a column in the resultant CSV download.
names	Yes	Type: comma delimited integer array Default: None	The year(s) for which data should be extracted.
utc	No	Type: true or false Default: true	Pass true to retrieve data with timestamps in UTC.
leap_day	No	Type: true or false Default: false	Pass true to retrieve data including leap day (where appropriate). Pass false to retrieve data excluding leap day.

full_name	No	Type: string Default: None	The full name of the user requesting data.
email	Yes	Type: email string Default: None	An active email for the user requesting data. This email will be used to deliver the extracted data.
affiliation	No	Type: string Default: None	The organization with which the user requesting the data is affiliated.
reason	No	Type: string Default: None	The reason that the user is requesting the data.

Table 3 shows the parameters that are used in the Matlab code API request URL

Table 3: Request Parameters used in the Matlab code

Parameter	**Required**	**Value**
api_key	Yes	DEMO
wkt	Yes	Latitude/longitude
attributes	Yes	wind_speed, power
names	Yes	2007,2008,2009,2010,2011,2012
utc	No	true
email	Yes	ben@gmail.com

7 Results & Conclusion

The graphical outputs from our Matlab script allow users to uncover important data regarding the peak and minimum hours, days, and seasons for wind power. Notably, as a result of our script we were able to confirm that the worst time for generating electrical power via wind is during the summer season and specifically from early morning to mid-day. Ironically, this is arguably when electrical power is needed the most due higher than normal appliance usage rates (air conditioners, fans, central air units, etc.). The best time for harvesting wind power according to our graphs is during the winter season specifically during early morning and late night. The supply of demand for electrical energy during this period of time is the highest but the demand is not necessarily as high as during the summer.

Due to the Matlab script we were successfully able to create data visualizations for an offshore wind site's diurnal power variation over a day and seasons over a day. In addition to this, we were also able to graph the daily power variability annually by season as well as just by the season for any site ID. This tool will be useful for researchers and developers who need to reference available wind data for any specific location.

References

[1] NYS Offshore Wind Master Plan. (n.d.). Retrieved May 1, 2020, from https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Offshore-Wind-in-New-York-State-Overview/NYS-Offshore-Wind-Master-Plan

[2] “What Are the Advantages and Disadvantages of Offshore Wind Farms?” American Geosciences Institute, 4 Jan. 2019, www.americangeosciences.org/critical-issues/faq/what-are-advantages-and-disadvantages-offshore-wind-farms.

[3] Dreyer. *The Benefits and Drawbacks of Offshore Wind Farms*, 15 Dec. 2017, large.stanford.edu/courses/2017/ph240/dreyer2/.