**Mapping U.S. Wind Turbines**

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Wind turbines as the free source of energy have received considerable attention especially in Europe and is also a growing industry in the U.S. Today, there are 58,185 turbines throughout the U.S. which provide total capacity of 90,500 MW for Americans.

On one hand there is an approach for renewable energy sources and specifically wind energy and on the other hand there are concerns for side effects of the turbines for environment and societies surrounding them. The paradox of two opposite approaches for installing wind turbines between protests and opponents who are usually local communities are called “gap” (Bell et al., 2005).¹

Furthermore, when communities and locals are absent in the process of decision making, it results in lack of transparency and trust. On the other hand, projects that involve locals in the process of decision making resulted in less opposition (Bak, 2012). In fact, transparency about wind turbines projects remove the gap which indicates negative ideas of communities about respective decision makers and sometimes vice versa. In other word, decision makers and especially the project owners usually are blamed for receiving the profit while the communities deal with wind turbines’ side effects.

**Necessity of mapping Wind Turbines**

Mapping wind turbines is mainly important in regard with health and environmental risk assessments. More importantly, mapping the wind turbines along with providing information about each turbine promotes the transparency between the decision makers and the involved communities.

In this regard, the Danish Ministry of Environment has provided an interactive map that let the end users to draw a buffer around each wind turbine in Denmark so as to define how much distance is between specific locations and wind turbines. It is mainly important because it has been reported that impact of wind turbines on human health depends on the visibility of the turbines from a person’s home. In fact, according to Office of Energy Resources in Rhode Island, the houses must be built in no less than 550 m from a turbine mainly because the transmitted noise made by wind turbines need to be less than 40 db in the houses ². This also indicates the importance of the accuracy of mapping wind turbines.

However, the most accurate way to collect data is to perform site visits and locate the turbines while standing at the base of turbines.

**Mapping Wind Turbines in the U.S. (USGS Dataset Review)**

The United States Wind Turbines Database (USWTDB)³ is an interactive web-based map which illustrates the location of each 58,185 individual wind turbines in the U.S. and provides their data.

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¹ Bell, D. Gray. T. Haggett C. (2005), the 'social gap' in wind farm siting decisions: explanations and policy responses Environ. Polit., 144 pp. 460-477

² [http://www.energy.ri.gov/documents/landwind/Guidelines%20Overview_OERFormat_FINAL.pdf](http://www.energy.ri.gov/documents/landwind/Guidelines%20Overview_OERFormat_FINAL.pdf)

³ [https://eerscmap.usgs.gov/uswtdb](https://eerscmap.usgs.gov/uswtdb)
including turbine ID, project name, year online, rated capacity, hub height, rotor diameter, total height, turbine manufacturer, turbine model, attribute confidence, location confidence, and last but not the least, latitude and longitude. Taking advantage of three data sources of LBNL\(^1\), USGS\(^2\), AWEA\(^3\), this interactive map provides users with series of easy-to-understand data on a right panel in which you can choose what type of data you are looking for. In fact, the panel remap the turbines according to the type of data which is important to the user. The data is presented based on areas with wind turbines that the user looks for in the U.S. and includes number of turbines in the window and the total rated capacity of selected area. The map also provides you with searching turbines by their different attributes including height, capacity and the year they were made. The color ramp in this interactive map enables you to categorize the above-mentioned classes with a color range from blue to red. When zoomed in an area, the list of wind turbines in the area and their specifications appear. Clicking on each project on the right panel takes you to the specific area in the map for more details and better view.

The other good point in this interactive map is being updated regularly. In Fact, being in the website mailing list let you stay updated on any changes and updates on the map. Raw data and metadata are also available for map makers to tailor it to their own purpose. The satellite view of this map shows the neighborhood appropriately in a way that the nearby roads and residential areas are visible.

However, an end user is unlikely to be able to measure the accurate distance of turbine to his residence. As mentioned earlier, the distance between residential areas and the wind turbines play important role in health issues. The measurement of the distances helps the communities earn clearer vision of the effects including noise, flicker effect on their health. In other word, although the wind turbine database is available for public access, easy application for measuring of distance between nearby turbines and residential areas is not included. In this regard, GIS and specifically ArcMap as well as google map can be a good tool to measure the distances. Taking advantage of calculating the distances, USWTDB can provide public with more precise information and be a perfect mapping tool for public.

To put it in nutshell, GIS plays an important role in acceptance of wind turbines within communities. In fact, it helps communities to figure out where exactly the turbines are along with giving easy-to-understand information about each turbine. It consequently promotes transparency between involved communities and project managers.

Annotated bibliography:

Douvere, 2008, the importance of marine spatial planning in advancing ecosystem-based sea use management. Journal of Marine Policy 32. 762-771

Douvere argues the necessity of clarity and better defining of marine spatial planning (MSP). She calls spatial planning as a solution in management because MSP is a process that “when and where human activities occur in marine spaces”. She also emphasizes that the multiple economic and environmental targets and reduction of conflict between communities and project managers require integrated approach to management which is taking advantage of spatial analysis. The most helpful part of this paper for my purposes was that she proved and supported the use of spatial
analysis in managing the use of a certain area (here it is ocean) so as to promote transparency among stakeholders.


Lee and his colleagues necessitate the precise calculation of wind turbines’ locations and their frequently updated status mainly because wind turbines affect radar systems. These radar systems are mainly for purpose of defense in different societies and therefore, precise location of wind turbines and their updated status is a must. To accomplish this, Lee and his team created an automated classifier with accuracy of 97% through taking advantage of convolutional neural networks (CNN), AlexNet and GoogleLeNet CNN, along with overhead imagery from Google maps. I suppose the idea of pairing GIS-based data with Google maps to achieve the highest accuracy for location and the most updated status of wind turbines is a smart concept. However, they can also take advantage of USWTDB for precise data about each turbine. They also need to apply this method for larger data sets because their sample for the test 6 turbines in a wind farm.


Bak in his paper evaluates and highlights the role of communities in the phase of planning for wind turbines and emphasizes that the presence of communities promotes transparency and consequently results into less local opposition against the wind turbines. His argument is important mainly because once communities are not happy with wind turbine sitting, the whole project will cancel. Furthermore, this matter is important because of recently wide spread and strong term NIMBY (Not In My Back Yard). It is a well-drafted paper to remind us of the role of communities while planning for wind turbines.

Miller, L and Keith,D, 2018, Observation-based solar and wind power capacity factors and power densities, *Environmental Research Letters, 13* 104008

Miller and Keit tried to find out power density and to do this, they started to quantify the area of US wind power plants. They calculated Voroni polygons by taking advantage of QGIS Development Plan for each wind turbine mapped in USWTDB. It was a new and smart application of GIS to quantify wind power in wind turbines. I suppose the big advantage of this study is that they only relied on solid location of every turbine.


They developed a geodesign framework which collects the input data that are necessary to be considered in planning for wind turbines and integrates them for the process of decision making. It is an interactive system that I suppose, takes the best use of GIS and all the data it receives and narrow them down and bring them on the same page. This paper is full of different kinds of data as
much as a book which is mainly because it is trying to be multi-disciplinary and integrate many different areas into one arena for making final decisions. Not many papers take advantage of this much of information and I suppose this paper is not only newest but also pioneer in planning for wind turbines with the use of GIS. They integrated GIS into a game engine and as you can see in the diagram below, GIS plays an important role in the process of decision making. I am impressed how multi-faceted this paper is. In fact, these kinds of papers which address multi aspects are most needed in the area of planning for wind turbines.

Mekonnen. D, Gorsevskib. V, 2015, a web-based participatory GIS (PGIS) for offshore wind farm suitability within Lake Erie, Ohio, Elsevier, Renewable and Sustainable Energy Reviews, 41. PP 162-177

GIS is the most common tool to find the most suitable sites for onshore and offshore wind turbines. In this paper, like the previous paper) they applied GIS in Decision Support System (DDS). With an emphasis on communities and transparency, they created a prototype that is a distributed and asynchronous PGIS (Participatory GIS) that combines a discussion forum, a mapping tool and a decision tool. In FACT, PGIS which is also used in USWTDB, paves the way for better understanding of the turbines whether for project managers or locals. However, this study covers Erie Lake in Ohio and have not been tested for bigger scale areas.

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i Lawrence Berkeley National Laboratory (Berkeley Lab) is a Department of Energy (DOE) Office of Science lab managed by University of California
ii U.S. Geological Survey
iii The American Wind Energy Association (AWEA) is the premier national trade association that represents the interests of America’s wind energy industry.