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Taking the NIMBY out of Large Wind:
Solving the Commonwealth's Wind Farm Siting Dilemma by Piggybacking on the Communications Infrastructure

Project Description and Significance:

The goal of this project was to find both physically and politically suitable on-shore locations for large-scale wind turbines or wind farms in Massachusetts. By physically suitable I mean that the sites should have a sufficient wind class rating, have a viable land use designation and be outside of population centers. By politically suitable I mean that the turbines/farms should be on sites that limit the level of public opposition, or NIMBYism, as much as possible.

Wind speeds are sufficient and physical sites are plenty in Massachusetts but the latter goal, that of finding politically and socially viable sites, has been very difficult to achieve in this state. The major reason for this is that residents care a great deal about protecting the natural environment around them from further destructive human development. This stance is very reasonable and understandable and it is one that I fully agree with. However, more and more environmentalists and naturalists, me being one, are beginning to understand that the potential disastrous impacts of global climate change from greenhouse gases released during the combustion of fossil fuels to provide energy will be far worse than the impact caused by erecting a limited number of large wind turbines or farms of wind turbines throughout the state that are intended to produce clean power that will help in the battle against global warming.

The vast majority of Massachusetts residents are in favor of utilizing more wind power but this has not prevented a small yet powerful and well financed opposition from slowing and preventing projects from getting off the ground through legal and bureaucratic red tape. This opposition claims environmental protection as their main argument against large wind but most are actually motivated by the fears of corrupted views from their homes, businesses, and recreation spots as well as reduced property values. I initially thought opposition to large wind was unique to Massachusetts or New

England because of the historical significance of the area but as I learned more about it I came to realize that this problem exists across much of the country and all around the world which means that even though my project will be focused solely on Massachusetts, it could have national and even global implications if pursued further.

Ever since I became aware of this opposition movement several years ago I have spent a good deal of time and thought on finding ways to circumvent the NIMBY, or Not In My BackYard, attitudes prevalent throughout the state; rather than stubbornly trying to support wind projects that would meet inevitable delays and often failure as so many others have done in the past. In my thinking I have come up with two possible strategies. The first way is via very offshore floating wind turbines that cannot be seen from shore. The problem is that floating wind turbine technology has not been perfected and is likely at least 5-15 years away from large-scale deployment. The second way is to find onshore locations for placing the wind turbines that will not generate public opposition, or at least limit it as much as possible. In Massachusetts there are unfortunately very few of these locations because even when planned on a deserted and unutilized Brownfield, a 1.5 Megawatt utility-scale turbine is so tall and wide and eye catching, not to mention often in motion and potentially deployed in large numbers, that opposition could still likely arise from any residence or community within a significant radius of the site.

My Solution: Policymakers should encourage large-scale wind developers to site their turbines on those many sites across the state that are already corrupted by human development with one, or often several, of large and unsightly radio, television, and cell phone transmission towers made of steel, wires, cables, support equipment, and blinking red lights. First off, these sites are often on hilltops so the wind is more likely to be strong, of course some sites will be better than others and distinguishing the best, from the good, from the mediocre, from the poor, and finally from the not viable sites will be a main goal of my project. Second, very few people, if any, would seriously attempt to protect my proposed sites as it has already been corrupted by human technology and infrastructure, so there will very likely be no long and drawn out NIMBY or environmental protection related siting issues. Third, these towers already need power to operate and are often already connected to the grid which would reduce the need for additional transmission lines. For those sites not connected to the grid, the wind energy could provide cleaner power than the backup generators and/or batteries used today. Fourth, access roads are already in place at these sites that were initially utilized during construction of the towers and they remain in good working order for those that maintain the towers so there is no need to construct new roads that would further impact the environment in a negative way. Fifth, these towers are generally made up of thin steel frames that will not significantly impact wind flow and wind strength nor create significant wind turbulence and while I am not a telecommunications expert it is my understanding that transmissions from these towers will not be interrupted by the spinning motion of the turbine blades, however, more research into both of these issues would be required.

My vision is of a ring of large wind turbines circling the site and surrounding the communications tower(s) at the center. In addition, although I have not fully investigated it via GIS in my project, this same idea, depending on wind strength and other siting issues, could also be applied to the large swaths of land that have been clear cut across the state to make room for high voltage power lines. For this project I hope to find and map possible sites across Massachusetts in GIS using a series of six separate data layers as variables to find all plot first class, second class, third class, fourth class and fifth class sites.

Data Layers and Sources:

Tower Presence and Tower Height: Alfredo Osorio, the extremely cooperative president of AntennaSearch.com, provided me with the MS Access database of all 4,248 towers in the Massachusetts, current through November 11th, 2007, free of charge. The database contained X, Y (latitude, longitude) information so after selecting the correct coordinate system I was able to accurately plot each tower in ArcGIS. With a standard 1.5 MW turbine pushing 400 feet tall, highly visible towers of at least 200 feet are a necessity to help mask out these large wind turbines that can draw attention and opposition. The height of each tower was a major focus of this project with taller towers being weighted more heavily when classifying the qualifying sites. A total of 1,157 of the total 4,248 towers met the minimum requirement with 675 towers between 200 & 299

feet, 254 standing between 300 & 399 feet, and 228 towers that were 400 feet or taller. The remaining 3,091 towers below 200 feet tall were excluded from further study.
Source: http://antennasearch.com/

Wind Class: This data source (originally in raster form) came from a company called AWS Truewind, LLC out of Albany, NY who worked in collaboration with the Massachusetts Technology Collaborative, the Connecticut Clean Energy Fund, and Northeast Utilities Systems to test, quantify, and map 2002-2003 average wind speeds at an elevation of 50 meters throughout New England at a 200 x 200 meter resolution. It was MassGIS and the Massachusetts Water Resource Authority (MWRA) that later reclassified the data into vector form, changed the projected coordinate system from WGS1984 to NAD183 SPC, clipped the data down to display Massachusetts only, and added a wind power density range for each class.

In mapping the wind data layer I first did a vector clip to the borders of Massachusetts so that only onshore wind levels were displayed as I was not looking at offshore wind levels and the high levels of offshore winds detracted from the visual impact onshore wind levels. I also hollowed out the color so that sites with wind classes of 1 (poor) and 2 (marginal) were not displayed as a wind class of at least 3, and preferably 4 or greater, is required for a feasible utility-scale wind project. Of the 4,248 tower sites in the state, a total of 1,690 met this minimum requirement with 1,185 located on a site with a wind class of at least 3 while 505 tower sites experience class 4 winds or greater.

Sources: http://www.mass.gov/mgis/windpower.htm
http://www.mass.gov/mgis/windspeed.htm

Land Use: The land use dataset that I utilized, labeled LU21_1999, breaks each parcel in the state down into 21 distinct land use designations that are accurate as of 1999. The data was collected using 1:25,000 aerial photography throughout 1990, 1991, 1992, 1995, and 1997 and was interpreted and then quantified by a group of agencies including MassGIS, UMass Amherst, the Cape Cod Commission, the MWRA, and the Executive Office of Transportation (EOT).

It cannot be assumed that every site with strong wind and a tall tower would be an ideal site for a wind farm. Land use restrictions make many areas off limits.

Accordingly, I have reclassified each parcel in the state and designated each as either 'Viable' (pasture, forest, woody perennial, mining, open land and waste sites) or 'Not Viable' (wetlands/water, residential, commercial, industrial, cropland, recreational and transportation). The 2,504 tower sites that were deemed 'Not Viable' have been excluded from further consideration.

Source: http://www.mass.gov/mgis/lus.htm

Population Density and Urban Proximity: The initial data used to create this map and conduct the spatial analysis must be credited to 2000 US Census that counts and publishes population data for every block, block group, and tract in the country while also providing information on the area, in dry and wet square miles and square acres, of each.

Creating a raster map of population density was necessary for two separate purposes. The first was to exclude the 2,356 towers in locations with a density greater than 1 person per square acre due to the fact that large wind developments in urban centers will likely attract more attention and thus opposition than those in more rural locales. The second purpose was to establish an 'urban proximity score' by measuring the distance of each rural tower to the closest population center. Those towers closer to, but not in, cities scored higher than more distant ones due to expected reduced future energy transmission costs into those cities if a project were to built.

Source: http://www.mass.gov/mgis/cen2000_blocks.htm

Major Road Proximity: This layer from the MA Executive Office of Transportation and Office of Transportation Planning is the official state-maintained street transportation dataset and depicts every major road in the state at a 1:5,000 scale. The layer is up to date through December 2006.

The proximity of each tower to a major road was determined and given an appropriate weighted score. Sites adjacent to roads scored high and those more distant scored lower due to ease of access for future development and maintenance. This 'Road Proximity Score' was computed with the 'Urban Proximity Score' to establish a 'Political Viability Score' that was later used in calculating the final 'Site Class Score'. Details on this process can be found below in the Major Steps section.

Source: http://www.mass.gov/mgis/eotroads.htm

Major Steps:

Note: A number of preliminary steps for each data layer are covered above so I will not be going over them again in detail in this space.

-After obtaining all of my full data layers, I began by splitting the land use variable classification for each tower site into either 'viable' or 'not viable' designations using attribute selection and then selected out all viable towers, again through attribute selection. Then I created a new layer of viable sites and dismissed all not viable towers from further consideration.

-I then wanted to conduct a similar process that would allow me to select out from further consideration all tower sites located in population centers, but I first had to use the spatial analyst tool to find the population density per acre of each point in the state. After this was completed I only continued to analyze tower sites located in a rural locations with a population density less than or equal to 1 per acre and dismissed all urban tower sites.

-This process also allowed me create a new variable, called 'Urban Proximity' that used the spatial analyst measuring tool to find the distance in miles from each rural tower site to the closest population center.

-Using a similar spatial analysis process I was able to create another variable, called 'Major Road Proximity' that measured the distance in miles from each tower site to the closest major road in the state.

-With this more limited data set of viable towers I next joined these urban proximity and major road proximity variables, as well as the wind class variable, to my viable tower attribute table.

-From here I created a new layer by selecting out and dismissing from further consideration all tower sites located in an area with less than a 3 class wind rating as well as all towers with a height of less than 200 feet.

-This left me with a total of 75 tower sites from the original 4,248 that met all minimum viability requirements contained in a condensed attribute table. From here I imported the table into a new Access database and used a series of queries in order to complete my weighting analysis that would allow me to break down these 75 qualifying tower sites into 5 different classes of sites based on how well they met my analysis criteria.

-In Access I first generalized the wind class from 5 ratings of 3-7 down to a 3 rating system of 1-3 by making a new column entitled ‘Wind Score’ where I used a formula to give sites with a wind class of 3 a score of 1, those with a wind class of 4 received a score of 2, and those with a wind class of 5-7 received a score of 3.

-I next used an Access formula to generalize the tower height data into a new column entitled ‘Height Score’ where those towers with a height of 200-299 feet received a score of 1, those between 300-399 scored a 2, and those that were 400+ feet received a score of 3.

-Next I created a ‘Road Proximity Score’ column by breaking down the distance to a major road for each site into 4 values in Access. Those 0-.499 mile away scored a 4, .5 to .999 scored a 3, 1-1.499 a 2, and those 1.5 miles away or greater received a 1.

-Then in a very similar fashion I used a formula to create an ‘Urban Proximity Score’ column by breaking down the distance to a population center for each site into 4 values in Access. Those .001-4.999 miles away scored a 4, 5 to 9.999 scored a 3, 10-19.999 a 2, and those 20 miles away or greater received a 1.

-In a new column I then added the Road Proximity Score to the Urban Proximity Score to create a ‘Political Viability Score A’ value of 2-8 for each site.

-Next I generalized the Political Viability Score A into a 3 class system called ‘Political Viability Score B’ where sites with a value of 2-6 were given a score of 1, those with a 7 scored a 2, and those with an maximum score of 8 received a 3.

-The last step in Access was to add up the Wind Score, Height Score, and Political Viability Score B in order to get the final ‘Site Class Score’ that ranged between a minimum of 3 and a maximum of 7 (no sites received a score of either 8 or 9).

-I then imported this table back into ArcGIS and mapped the ‘Site Class Score’ for each of the 75 qualifying sites.

-Finally I created a series of maps that highlighted certain regions across the state that had strong groupings of viable sites before zooming in even closer on specific areas that most stood out and downloaded aerial photos in order to help further visualize those sites.

Difficulties:

Overall this project went surprisingly smoothly. It was a long process and required many steps but the set backs were few and far between and I felt steady progress for the most part each time I set to work on the project. Those difficulties I did experience included:

1) My lack of full and complete understanding of the spatial analysis conducted with you to find population density, urban proximity, major road proximity, and to build the new condensed data table that joined these variables and the wind class rating with the existing tower database. While I understood the concept of what we were doing at each step I do not believe I could precisely repeat the ArcGIS functions that we performed. I think this has to do with the fact that we were in a hurry and it was my first time conducting the process in a non-tutorial applied fashion. I look forward to conducting further spatial analysis procedures for my thesis and in my future career that will help me to further grasp each step more fully.

2) Clipping the raster map for population density/urban proximity gave me ongoing trouble; I was glad to learn the procedure in the end.

3) Storage space issues on the H: were constant because of the amount of data I was dealing with. The purchase of a 1 gigabyte jump drive a couple of weeks ago saved a great deal of my sanity.

4) Working with selecting and reclassifying the land use data layer crashed ArcGIS about a dozen times before getting it right because of the amount of data in that layer.

5) I kept losing data layers from session to session that I did not export or that I pulled from the M: Drive instead of a personal drive. Having to repair my data sources each time proved to be very inconvenient and time consuming but these troubles diminished as I began to grasp which layers I did and did not need to save locally.

6) I have had very limited experience with Microsoft Access so learning how to successfully operate this program in addition to running queries and writing formula equations proved difficult. However, I am glad for the experience and feel a great deal more comfortable with Access now which will help me in the future.

Concluding Thoughts:

In the end I thought my final approach worked out very well. I am glad for the experience working with ArcGIS and proud of my final product. However, looking back there are some changes that I would make if I were to do it all over again. First of all the wind class data layer at a 50 meter elevation needs to be replaced with 70 or 100 meter data as these heights would be far more applicable to the utility-scale wind turbines that I am proposing sites for. This information exists and is easily accessible from MassGIS but unfortunately I discovered it too late into the process. Second, as I have driven around the state throughout the last month I have begun to feel that I left out too many towers located in more populated areas. The whole point of this project was that these wind turbines/farms could be placed on any viable site with a large communication tower because the site is already corrupted by human development. The fact that a site is near a more heavily populated area should of course be taken into consideration and weighted accordingly in terms of classing but it should not be excluded entirely. And third, when selecting my viable and not viable land use designations I should have included Cropland in my viable selection as more and more farmers across the country are starting to harvest wind just like they harvest other crops and farms are often ideal places to implement large wind projects. This is especially true with the expected legislation coming out of the 2007 Farm Bill in Congress which strongly promotes, supports and funds renewable energy projects such as wind energy on U.S. farms.

When it comes to suggestions for future research, I have many suggestions:

1) Research into town/city by-laws regarding wind
2) Investigate the potential support level of energy utilities for this idea
3) Investigate the potential support level of the communication tower owners for this idea
4) Investigate the potential support level of the land owners (if different) for this idea after discovering who holds the deed
5) Investigate the potential support level of the community for this idea

6) Find the cost of the land to see if purchasing might be a realistic option for an interested entity and if so then get in touch with a wind turbine manufacturer/supplier and contractor about purchasing and installing
7) Find out details on expected up front investment, return on investment, potential energy production, and length of payback on such an investment
8) Conduct an on-site year long average wind strength analysis for the most promising sites using anemometers
9) Pursue a parallel GIS study that looks at finding additional potential sites along high and medium voltage power lines that run across the state
10) Investigate the presence and the level of impact that a large-scale wind turbine/farm might have on communication transmissions as well as the potential unwanted wind turbulence that a large communication tower might cause and the impact it might have on the energy output on a turbine/farm
11) Design site layout plans for implementing wind energy into these sites

Finally, as for my next potential step in working with this idea I have several potential plans of attack:

1) Develop this idea into a formal business plan by February 14th and enter it into the 2008 MIT/MTC Ignite Clean Energy competition that just kicked off last week.
2) Get in touch with a developer or a utility about the possibility of implementing the idea through the private sector.
3) Get in touch with my contacts in the Office of Environmental and Energy Affairs at the State House and pitch it to them.
4) Get in touch with the Alliance to Protect Nantucket Sound and Ted Kennedy about pitching this idea to them so that they can use it as an alternative proposal to Cape Wind in order to follow up on their claim to support wind energy in general but just not in the Sound. Because of the high number of qualifying sites on the Cape and Islands this alternative could have some real potential and may help to finally end the ongoing bickering, delay, and red tape that the Cape Wind project has created over the past 5 years.