Capturing Natural Energy: Proposal for Montana Wind Development

Catherine Klem
GIS Final Project- 992 words
Introduction

Over the last century, energy consumption in the U.S. has increased rapidly, leading to a heightened demand on traditional energy sources. As recent research has pointed to the harmful environmental effects and unsustainable use of current fossil fuel-based energy sources, it has become more pertinent than ever to seek alternatives. Wind energy, a non-polluting energy source, has emerged as a strong alternative due to its relatively low cost of implementation and low maintenance demands.\(^1\) Ranking 5\(^{th}\) nationally for wind power potential but only 16\(^{th}\) for production, Montana has wide open tracts of prairie-based land in the central and eastern part of the state which are ideal for development. Despite its great potential, careful site selection and community-based analysis must be done to find locations where not only is the wind potential the best but development also supports and incorporates local communities. Successful implementation will also be environmentally conscious not only in the outcome but in the process as well through minimal landscape impact and construction needs.

This study uses GIS analysis to address these main concerns in the identification and assessment of the top five incorporated cities in Montana with the greatest potential to harness and utilize wind power. A total of 1,791,250,000 acres of ideal developable land are identified, which could significantly decrease Montana’s current dependence on carbon and hydroelectric sources. This report details site suitability based on physical constraints (land development potential and wind availability), socio-economic concerns (ways in which wind development can support the local community), and viewshed analysis (strategies to decrease the visual impact of wind turbines in scenic areas and towns). The report then gives a detailed analysis of the top five sites exploring in depth their suitability based on the above criteria.

\(^1\) GLI Editors *The Benefits of Wind Power* http://greenlivingideas.com/topics/alternative-energy/wind-energy/the-benefits-of-wind-power
Located in the northwestern U.S., Montana’s great expanses of open land have dubbed it the Big Sky State. While the Rocky Mountains dominate western Montana, middle and eastern prairie-dominated land provide plenty of open space for wind development. Montana is one of the U.S.’s largest states, but with just under 1 million people it ranks 44th in the nation in terms of population. Montana’s top industries are farming, cattle ranching, mining, oil, lumber, and tourism.
Methods

*Physical Land Constraints*

One of the first steps in site selection is finding tracts of land which can be easily developed with minimal landscape alteration. The terrain must be relatively flat and devoid of large amounts of trees or infrastructure, and of course the availability of wind is of utmost importance. An equally important issue in site selection is the ability to distribute the produced energy. Proximity to existing infrastructure is thus very important as the construction of new roads, transmission lines and power generation sites to the new development can be incredibly expensive as well as energy intensive.
Identifying Unsuitable Terrain

BLM Special Land

Wilderness Areas

National Parks

Wildlife refuges and management areas

Wind Classification less than 4

Lakes and Major Rivers

Suitable Terrain given all Constraints

In many places throughout Montana land development laws and physical land properties make wind farm development impossible. These sites were identified and eliminated from the analysis. BLM special lands, wilderness areas, and National Parks were all removed as they have strict land development laws which would prevent development. Additionally, a large debate regarding the negative impact of wind turbines on animal habitat would likely preclude the development in wildlife management areas and refuges, and so these areas were also eliminated. Lakes and major rivers and areas with too little wind to make turbines viable were also eliminated from the analysis. A final map highlights all viable terrain which was considered in the analysis.
Land suitability for wind energy development was assessed based on land coverage, wind, and slope. Land coverage was used to isolate areas where high density development, water or trees would make development hard while barren or grassy lands would be best suited for development. Wind was classified linearly where the highest wind classes are most suitable while wind classes below 4 are insufficient. Slopes were also assessed linearly where a completely flat surface is most easily developed while a 20 degree slope is not particularly suitable. To build on a slope greater than 20 degrees significant landscaping and filling (which would be both costly and energy intensive) would be required and thus such landscapes are unsuitable.
Land suitability was assessed based on proximity to existing infrastructure. Land was classified based on whether it was in a 1, 10 or 20 mile radius of existing power generation sites. Outside of a 20 mile radius, energy lost in transportation and necessary transmission lines were considered to be too great to make the availability of an existing power generation site worthwhile. Transmission lines were similarly assessed giving higher priority to sites in close proximity to existing lines. Distance to major roads and highways was also analyzed, as it was assumed that roads to the sites will be necessary to facilitate transportation of supplies and routine maintenance of the sites. Only paved roads were considered in the analysis as it was assumed that dirt roads would not support the heavy machinery used in construction.
Land suitability assessment in conjunction with proximity to existing infrastructure was combined to analyze general physical suitability. To do so, each attribute was weighted based on its relative importance in site selection. The presence of wind was considered the most important as it is integral to the development of wind power and cannot otherwise be altered by human processes. Proximity to power generation sites and proximity to roads were slightly less important as they could greatly reduce costs of construction but are not absolutely necessary for site construction. Land Coverage and slope were given slightly less importance as the landscape can relatively easily be altered to create flat grassy lands ideal for wind turbine placement. Proximity to transmission lines was given the least importance as current lines are near capacity and have little space for expanded energy loads and thus new lines would likely have to be constructed as is. All land was classified on a scale of 0 to 10 where a 10 would represent an area that classifies as ideal for every given constraint, while a 0 would be unsuitable for every given constraint.
Socio-economic analysis

Traditionally one of the major issues with wind power development spurs from the “not in my backyard” argument expressed by locals who fear that not only will wind farms have a strong visual effect but they can also have a strong economic impact. Research has shown that views marred by wind farms have led to decreased tourism as well as drops in hotel and vacation rates. In a state like Montana, where tourism is one of the leading economic industries, this is a very serious concern. However, if properly implemented, wind development can actually support the economy through job creation and, consequently increased housing demands. Socio-economic analysis sought to address community needs as well as enhance the potential economic benefits of implementation.

^2 Haughton, J. et al. *An Economic Analysis of a Wind Farm in Nantucket Sound*  
If done carefully wind development can have a positive impact on the local economy. For one, the necessary construction and maintenance work creates employment. Thus counties with higher unemployment rates were given higher priority for development sites. Further counties with large numbers of unoccupied houses were also given priority. The theory here is twofold. For one, unoccupied houses means that the wind farm development is not destroying a homeowners established view. Also, job creation by wind development may bring in workers who can then settle in these houses and consequently support the housing industry. Along these lines, wind development in established neighborhoods will likely upset many citizens as it negatively impacts views and can lower property values. Consequently all areas within a 5 mile radius of a town were classified as unfavorable areas for development. Finally, land was classified based on whether it was private or public and whether it would be expensive and legally burdensome to secure the given land.
The socio-economic suitability for wind development was analyzed based on high unemployment rates, the presence of vacant houses, distance from populated towns, and the ease of acquiring and developing land. All attributes with the exception of proximity to towns were given equal weight in the final analysis. The proximity to towns was given significantly less weight as it was acknowledged that it would be impractical to identify areas which are far from towns but within commuting distance of incorporated cities (the ultimate goal). Also, the visual impact of wind turbines on towns was analyzed separately. All land was classified on a scale of 0 to 10 where a 10 would represent an area that classifies as ideal for every given attribute, while a 0 would be unsuitable for every attribute.
**Viewshed analysis**

Wind turbines, standing 330 ft. from blade to tip, have a significant visual impact on the landscape. To some they are a beautiful exhibition of clean energy production, a form of environmental art. But to most, wind turbines pollute the natural beauty and undeveloped landscape of the Big Sky state. Viewshed analysis identified places where the visual impact of wind turbines is the least intrusive.
Viewshed Analysis:
How Can we Reduce the Visual Impact of Wind Development?
(Based on a scale from 1 to 10, where 10 is the most suitable and 0 is the least)

The three viewshed analyses were combined to investigate the visual impact of sites throughout Montana. The view from the towns were given slightly less weight than from the trails as it is impractical to suggest that wind farms will have no visual impact as towns are so widespread throughout the state. Each location was scaled from 0 to 10 where the presence of a wind turbine in a site of value 10 would have a significant impact on the view while a wind turbine in a site of value 0 would have no visual impact. All analysis assumes an average viewer height of 5.5 feet and a wind turbine height of 330 feet.

Viewshed analysis investigated the visual impact of wind development based on how many places a point could be seen from the Continental Divide Trail, the Lewis and Clark Trail, and towns. The two trails were picked for analysis as they represent places in Montana where people come to get away from civilization and enjoy the beauty of wilderness. Other wilderness areas were not included in analysis with the hopes that in fact wind turbines will be visible from wilderness areas and used to educate the public regarding the beauty of harnessing clean energy. Viewsheds were also run for all towns in Montana, as wind development should not impose on peoples’ existing views and doing so would probably foster local resentment.
Data Management

Each criterion was weighted based on its relative importance to the analysis and then all criteria were considered collectively and used to reclassify terrain as ideal, suitable or unsuitable. All land within a 30km radius of an incorporated city was identified, assuming that this would be a reasonable commute distance from the cities for construction and maintenance workers. Outside a 30 km radius commute distances as well as necessary roads and infrastructure would be both too costly and energy intensive to justify development. Further, it was assumed that due to high start-up costs necessitated by the construction of new roads, transmission lines, power generation sites, and labor economies of scale are extremely important in site development, and thus the cities with the greatest area of ideal terrain were chosen to have the greatest potential.

Results

Cut Bank, Chinook, Fort Benton, Conrad, and Harlowton were identified as the top five incorporated cities in Montana with the best potential to develop and utilize wind energy. All located on flat prairie land in close proximity to existing infrastructure, the sites provide a combined 1,791,250,000 acres of ideal land for wind farm development.
All five incorporated cities are located within close proximity of highways and transmission lines. Most notably is the distance between all cities and existing power generation sites. The distance does have potential benefits as it could help distinguish between new clean energy sources located in northern Montana and the traditional and dirty coal-based energy to the south. A cost analysis however could better analyze the impact of the location of power generation sites.
The city of Cut Bank has a total of 176,680 acres of ideal land for wind development. This would provide space for 265,020 turbines. The surrounding terrain is very flat making for ideal building terrain. Cut Bank offers especially interesting socio-economic criteria. For one, other than two small towns in close proximity, it is relatively removed from towns and thus will have little impact on residential areas. Further it is located close to one of the counties with the highest unemployment rates. Construction and site maintenance needs will provide much needed jobs to the surrounding counties. Further, located on the outskirts of an Indian Reservation the Cut Bank site has the potential to incorporate the Indian Reservation. While site construction does not dictate use of Indian land, if the reservation feels that its involvement would be economically beneficial, the site’s proximity provides an easy opportunity for them to incorporate wind development onto their own land.
The city of Chinook has 103,228 ideal acres for wind power development and could potentially fit 154,842 turbines in a 30 km proximity. It is especially ideal due to its location in an area of high unemployment (construction and maintenance needs will help create jobs in this area), and limited visual impact on the Continental Divide Trail. It is also predominantly located in grasslands, herbaceous areas, and pastures necessitating little site adjustment to make it suitable for development. The southern section of this site is also dominated by high winds which will optimize efficiency.
Fort Benton has 64,371 acres of ideal wind development land which could provide space for 96,557 turbines. It is particularly well suited due to large amounts of high wind and land cover which is dominated by grass and herbaceous land, and cultivated crops. The cultivated cropland, while easily developed, may be hard to obtain if it represents important farmland. Thus field analysis could work with local farmers to further assess the suitability of this site and do a more in depth investigation of how the land is being used. Also of note, the ideal land is relatively segmented and in many cases surrounded by unsuitable land. Field analysis thus should also investigate how easily the landscape can be altered to connect areas of ideal land.
Within a 30 km radius of Conrad there are 64,371 acres of ideal land providing space for 96,557 turbines. The main advantages of Conrad are high winds and a very flat slope. Some drawbacks however are that a wind farm near Conrad would be very visible from both the Continental Divide and the Lewis and Clark Trails. One solution to this is to embrace the view of the wind farm stressing to hikers the relation between its presence and the maintenance of the clean, pristine environment that they are enjoying. The other major issue with Conrad is that the ideal land is broken up into small pieces rather than being part of one large tract. This means that likely less than 96,557 turbines could fit. The land is generally surrounded by suitable land however, so perhaps this suitable land could be used as well to link spaces of ideal land.
The Harlowton site provides 45,653 ideal acres for wind development providing area for 68,480 wind turbines. There are sections around Harlowton which are extremely well suited to wind development most notably due to the presence of high wind speeds and the limited visual impact it will have on both views from the Continental Divide Trail and the surrounding towns. One interesting aspect of the Harlowton site is that it is almost entirely located on private land. This may make development somewhat more expensive due to property and permit costs, but it will avoid the intricacies of federal development laws. The major drawback to the Harlowton site is that ideal land is very segmented and thus with lost land due to the imperfect fitting of wind turbines, likely far fewer than predicted turbines will actually fit. The ideal land is however surrounded by suitable land which can likely be used to connect ideal land spaces.
Conclusions

The next step in the implementation of wind farms would be to site-check and individually assess cities identified by GIS analysis to better understand local considerations. Much of this analysis was performed using 100m resolution (viewshed analysis used 500m resolution), and thus site inspection is important in identifying smaller-scale intricacies which may play an important role in landscape viability. Also due to the dynamic nature of the landscape, site inspection will identify qualities which may have changed since the data was collected. Additionally, criteria were chosen using statistical evidence from previous wind developments as well as general logic. Because however the support of the state of Montana is of the upmost importance in the development of a wind farm, a more thorough analysis would poll local citizens as well as potential tourists to more accurately weight constraints based on constituent needs and interests. Perhaps of greatest concern is the distance from each of the identified sites to an existing power generation structure. Thus, future work should include a more in depth cost analysis of the construction of new structures or the potential to use existing ones despite their distance. Depending on findings, GIS analysis can be rerun assigning more weight to the proximity of power generation sites.