Wind Power Development Potential in Montana
A spatial analysis of local wind power resources

Stephanie Joyce
Middlebury College
GIS Final
Fall 2009
The era of dependence on non-renewable resources such as oil and coal is coming to an end as supplies dwindle and their economic and social costs rise. The development of renewable energy resources such as wind, water and solar power is becoming increasingly important to meet power demands and national emissions goals. In 2008 the Department of Energy released a report entitled “20% Wind Energy by 2030” in which it lays out national plans for increasing wind production in the coming decades. Montana is a state with tremendous potential for energy generation from wind power, ranked as 5th in the nation by the American Wind Energy Association. The development of local wind resources to help power Montana’s cities can help make the state a leader in green energy, creating jobs and lowering power costs in the process.

This report takes a sequenced approach to isolating areas with high potential for local wind power development in Montana with the goal of identifying the top five incorporated cities with local wind resources. The first section of the report assesses physical and economic constraints limiting suitability. The second section identifies the top five cities with large areas of highly suitable land nearby. The third section considers the visual impacts of wind turbine installation on the identified sites. The fourth section demonstrates possible solutions to expanding the existing power grid to link the top five cities to wind power generation sites.
Wind Power Development
An analysis of physical and social factors contributing to suitability

The suitability of areas for wind power development can be assessed based on evaluation of a variety of physical and social variables. For this analysis, six physical and two social variables were considered (see table). The weighting of these factors was based on evaluation of relative importance, however, it is necessary to keep in mind that these criteria could have been weighted differently, producing different results.

Each physical variable was given a unique weight (e.g., wind = 20%) and then the suitability of its subclasses (e.g., Wind Classes) was assessed by assigning a number score from 0-10. Wind power classes 6 and 7 have wind speeds > 17.9 mph at 50m, which is considered excellent. Areas of grassland or shrubs were considered to be most suitable for wind farms because they do not require the clearing of lands, which can contribute to a release of carbon dioxide into the atmosphere. Proximity to cities was considered to be advantageous outside of a 5km radius, but within a 20km radius, taking into account that placing wind turbines inside cities is unlikely to be popular, but prioritizing local power generation. Proximity to existing roads and transmission lines was considered important as it is economically unviable to construct completely new infrastructure, although extending existing infrastructure might be possible. Slope was taken into account with the construction of access roads in mind. Elevation was considered to account for potential problems with ice and snow.

The two social variables considered were given equal weight. Counties with high poverty levels were considered more suitable because of the potential for job creation from wind farms as well as the potential for cheaper long-term energy costs. Counties with large populations of young people (defined as age 16-25) were considered more suitable based on the assumption that young people are more open to alternative energy sources.
This map combines the physical and social variables considered in the previous maps as well as constraints on land use. Physical variables are weighted as 70% and social variables 30% in the combined analysis, giving greater emphasis to the suitability of the landscape than social factors. This map also excludes a number of areas (see table) that are considered unbuildable.
By isolating areas of very high suitability from the combined analysis map it is possible to select for only the most desirable areas to build wind farms. In this case, areas within the top 15% of the suitability index were chosen. These areas were subdivided into two different classes: large areas of high suitability (>100 acres) and small areas of high suitability (<100 acres). Subsequent to establishing these areas, each incorporated city was evaluated for how many areas of high suitability were within a 20 kilometer radius of the city. The table listing the top five cities is indicative of the total number of highly suitable areas within this buffer.

<table>
<thead>
<tr>
<th>Cities</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Big Timber</td>
<td>1557</td>
</tr>
<tr>
<td>2. Cut Bank</td>
<td>3329</td>
</tr>
<tr>
<td>3. Livingston</td>
<td>6701</td>
</tr>
<tr>
<td>4. Chinook</td>
<td>1497</td>
</tr>
<tr>
<td>5. Havre</td>
<td>10322</td>
</tr>
</tbody>
</table>
Visibility Analysis
An analysis of wind turbine visibility from key locations

Wind power is often controversial because people consider wind turbines a blemish on the landscape. This analysis considers what areas would be visually impacted by the placement of wind farms in the sites that have been identified as areas of high suitability. The first part of this analysis considers the visibility of wind turbines from town centers with a limitation on visibility of 20 kilometers. The second part considers visibility from the Lewis and Clark trail, which attracts many visitors to Montana. Ideal sites would lie outside of both visibility ranges. This analysis should be corroborated on the ground because it does not take into account vegetation and other potential obstacles to visibility. However, based solely on this analysis, there appear to be limited areas that are not visible from either city centers or the Lewis and Clark Trail.
Linking Wind Sites to Cities

New power generation projects have to be connected to cities and the easiest way to do this is to expand existing infrastructure. For the largest potential wind sites near the selected cities, the most efficient path for new transmission lines was calculated. Although priority was given to following existing transmission lines, new transmission tower paths were also considered, taking into account land cover. Paths following existing road infrastructure were also considered to be efficient, although less so than existing transmission lines. This analysis should be cross-referenced with field data.
An Assessment of Error and Conclusions

The sites selected by this analysis represent only a small number of the possible sites for local wind power development in Montana. Had different criteria been used in the evaluation it would have produced different, but not necessarily less accurate results. In order to more accurately assess whether the selected sites are suitable for a particular project they should be verified by field data and the variables involved in this analysis should be considered in comparison to the desired criteria. Future work might include consideration of more variables, such as public vs. private land, capacity to expand the existing power grid and local political response to wind power. It might also be valuable to analyze changes in the results as a result of different weighting of the assessed variables.

One of the key errors in this analysis derives from the different resolutions or accuracies of the different variables. The dataset representing wind power is accurate only for a 400m by 400m area while all of the other variables are accurate for areas of 90m by 90m. In order to not lose the accuracy of the other layers, the 400m image was converted to an artificially precise 90m image. This changes the boundaries of the categories, in fact making the wind data more imprecise. Consequently, suggested sites should be verified by field data.

The analysis linking wind sites to cities is subject to significant error because its path is chosen on a cell by cell basis, meaning that it does not take into account the possibility that temporary deviation might ultimately lead to a better path. Also, although priority was given to paths following existing transmission lines, there is no guarantee that the lines have any additional load capacity. It also does not take into account whether the land being crossed is public or private. As with the rest of this analysis, all results should be verified by field data.