Metropolia UAS, Sustainable Energy Design Project

Wind power park site planning and mapping with QGIS

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1. Introduction

The Wind power park “Pikku Berliini” with a capability of approximately 300 GWh was designed into northern parts of Finland. This report will cover the basis of choosing this specific location and the feasibility of the possible installation of the park.

A schematic map was also created of this wind park and it is analysed and presented in this report. The wind park design and the creation of the map were a successful and very educational project.

2. Location of the wind park

In this chapter, the reasons for the chosen area for the wind park should be given, first the location of the area in Finland and then the concrete place of the wind park in this area.

2.1 Location of the area in Finland

The main factor when choosing a suitable location for a wind park in Finland is, obviously, the wind. However, you have to look at the wind in more detail, as the wind is not the same in whole Finland. First of all, cold air is better for producing wind power than warm air. Reason for that is that cold air has a higher density and therefore it produces more energy at the same wind speed than warm air (Finnish Wind Power Association (1)). This means at the same time that the wind power production is also the highest in the winter months, when the heating energy consumption is also at its maximum. Moreover, this leads to the conclusion that the lower the temperatures are, the colder the air is and thus the better the wind conditions for a wind park are. Additionally, the winter months are usually windier than the summer months, which means that there is more wind available in colder conditions where the winter lasts longer. With regard to the region, the temperatures are the lowest (and in their duration throughout the year the longest) in the northern parts of Finland. Another aspect is the amount or the strength of the wind which is available. Generally spoken, the wind is stronger in high elevations like highland areas (the wind speed increases with distance from the ground), in offshore areas and at the coast. Due to the circumstance that offshore areas should not be considered in this project, the nearest conclusion you might draw is that the best place for a wind park would be the top of a fell in northern Lapland. Nonetheless, there are couple of difficulties involved in this consideration:

(1) On a Lappish fell there is usually not enough space for a whole wind park but just for single wind turbines. In the rare case that there should be more space, there will be the problem that
(2) The turbines might be forced to be built on a high slope, which would lead to much higher installation costs.
(3) The wind park might be far away from the next consumers, which would increase the costs of transmission of the generated electricity.

For this reason, the coast at the northern part of the Gulf of Bothnia was chosen as a location for the wind park designed in this project, because it provides (a) colder air than in the south, (b) stronger winds than in the inland and (c) it does not represent the disadvantages of the highland in Lapland.

However, there is also a disadvantage of cold climate sites. Are the temperatures too low, atmospheric icing can occur when there are liquid water droplets in the air. The type, amount and density of ice formations depend on both meteorological conditions and on the dimensions and type of structure or object (moving/static) (IEA wind, 2012, 10). Due to icing or low temperature the turbine needs to be shut down which leads to production losses (IEA wind, 2012, 38). Besides, a lot of anti-icing technologies have been developed and tested successfully in the meanwhile to prevent this atmospheric icing. Hence, icing of the rotor blades should not be considered in this project.

2.2 Specific location of the wind park in the chosen area

Apart from the wind resources, there are also other criteria that need to be considered in the choice for the wind park location. For instance, the distance between the wind park and the consumers of the generated electricity is of importance, because transmission of electricity causes power losses proportional to the root mean square of the current. The more far away a wind park is located, the more transmission is required, and the more power losses will occur. When wind turbines are located near consumers, less transmission is necessary and therefore power losses decrease (Finnish Wind Power Association (2)). For this reason, the wind park “Pikku Berliini” is located more near residential and industrial areas, to minimize possible power losses.

Another advantage of the chosen location is that there is as good as no relevant slope in this area, which makes the installation of the turbines much easier and, above all, cheaper.

Furthermore, the wind resources at this special section of the cost provides quite good wind resources. According to the Finnish Wind Atlas, the planned 30 wind turbines would be able to generate a yearly amount of electricity of 292.000 – 352.000 MWh = 292 – 352 GWh (see map in the appendix). Of course, this value depends also on a lot of other factors, such as the concrete type of wind turbine (hub height, rotor diameter …) and the actual real conditions on site. This value is based on the assumption of a WinWind WWD-3 D90-3 MW-wind turbine with a rotor diameter of 90 m (Finnish Meteorological Institute (FMI) 2008), and it might differ in case that other turbines are used.

Additionally, the infrastructure in this region is quite good fully-developed already, which means that there are electric grids for the feeding of the generated electricity very close and there are also already some small roads in the wind park area, which represent a good basis to install the service roads to the different wind turbines from there onward.

When defining the specific location of each of the wind turbines in the chosen area, it was assumed that there has to be at least a distance of five rotor diameters between two turbines in the prevailing wind direction, and three rotor diameters in the secondary wind direction (Seifert H., Kröning J. etc. 2003, 80). Because the concrete direction of the wind is unfortunately not known in any detail, a distance of five diameters was taken for every wind turbine. For the sake of simplicity, the wind turbines were placed slanting in the simple supposition that the wind comes from the sea, from south-west (see map in the appendix).

The whole wind park "Pikku Berliini" covers an area of around 10,724 km².

3. Explanation of the raster calculation weights

In the following part, the choice of our final location for the wind park should be explained, according to the raster calculation in QGIS. In the consideration, three different aspects were included: the wind data, the elevation of the surface and the slope. Of course, you can consider much more factors as well, to make your function more precise and to take into account more data, which will lead to better results (the more aspects were considered, the more reliable is the result), for example the terrain conditions of the area (like vulnerability for erosion or consistence of the ground, which are important for the foundation and the stability of the wind turbine) or the distance to near residential areas. The last aspect is not only of importance because of the visibility of the turbines, but also because of the noise emissions of them, which might be subject to limit values regulated by law. Moreover, also the availability of a good infrastructure is important, not just for the maintenance of the turbines, but even for their installation, since the transport of the materials, the workers and especially the rotor blades requires wide and solid roads. Finally, the accessibility to the electrical grid is an important factor when choose a suitable location for a wind park, because the distance between wind turbine and mains supply can be a decisive criterion if an economic feasible operation of the turbine is possible or not. However, the last two aspects were at least taken into account manually after doing the raster calculation.

Although the wind data obtained from the Finnish Wind Atlas do neither consider the direction of the wind, nor the availability of possible obstacles (local obstacles like houses, trees or bridges can change the speed and the direction of the wind significantly) or the air density and temperature (as said, cold air has a higher density and therefore it generates more power), the data of the wind power production are more useful for the calculation of the final function than the mere data of the wind speed.

The final function used for the calculation of the three rasters Wind Data, DEM and Slope was the following:

("DEM files@1") *0.1 + ("Slope@1") *0.2 + ("Wind data MS band 3 reclassified@1") *0.7

For the wind data a weight of 70%, for the elevation a weight of 10% and for the slope a weight of 20% were assumed. The elevation was given the most less weight, because at the chosen area at the coast there is as good as no elevation of relevance which might affect the decision for the location for the wind park and the elevation is nearly the same at any place in the region at a low level. The same is also valid for the slope, because at the coastal area there is less slope as well. However, the slope was given 20% weight because it would have still more influence on the decision than the elevation, since there is some slope in this area (though it is minimal, in relation) and the slope affects especially the costs of the installation of the wind turbines. The vast majority of weight was given to the wind conditions themselves with 70%, because they differ partly significantly in coastal areas, so that it is important to be aware of getting the best part of it for the wind park, as it is the same in the chosen area.

According to the new raster obtained by using this function, and under consideration of the aspects mentioned above, finally the specific location of the wind park “Pikku Berliini” was defined.

4. Analysis of the feasibility of the chosen place

In practice, there are some factors which might set a limit to the feasibility of the wind park.

First of all, in Finland locals often strongly oppose wind turbines in their “neighbourhood” because they “ruin the landscape”. This represents a big problem when planning a wind park, because those people often hinder and delay the process of implementation into practice by making it harder to get the necessary approvals, permissions and the acceptance and the support of the population, which is actually indispensable to establish and develop the sector of renewable energy in Finland further. In case of the wind park “Pikku Berliini”, this might be the limited factor for putting it into practice. Though they would be the advantages of easy grid access, good infrastructure, less slope and good wind resources, the wind park would be still just too close to the local residents to make it feasible to build it there. One option would be to decrease the number of wind turbines in the park (30 is just the maximum number and, admittedly, quite high) and thus to make the park smaller so that its sight does not give a reason to complain about so much. But however, it can be seen critically whether this would really find acceptance among the local population. For this reason, the wind park “Pikku Berliini” just represents an ideal and will not be able to become realized some day. To build such a big wind park of this size in Finland, it has to be far away from any residentials (no possibility of building it at the coast), though the wind and site conditions would be more likely worse at this place in the inland. This might also explain why the majority of the actual wind parks in Finland are of smaller size or even consist just of a couple of single turbines.

Another militating factor for the wind park “Pikku Berliini” might be the terrain of the chosen area. The terrain consists mainly of forests and fields, but with a lot of marshes and ponds around (National Land Survey of Finland (NLS), Google Maps). This may cause a ground which is less suitable for the foundation of the wind turbines, so that either less stability is guaranteed or the costs for the installation of the foundation will increase rapidly.

All in all, the conditions in the chosen area are basically very good to build a wind park there: Good wind resources, as good as no slope, easy grid access, fully developed infrastructure and a location near to the consumers of the produced electricity. Nevertheless, the designed wind park “Pikku Berliini” is still not feasible in practice because of too big proximity to residential areas and therefore a high opposition of the locals against the wind park, which will make it very difficult to get the permission for implementing it, and because of uncertain terrain.

5. Cartographic design of the map

The map type represents a thematic map. It is designed for specific audience, in this case for people who would be interested about this wind park (people living close to the area, investors etc). The map itself contains the following elements:

- Title
- Credits
- Legend
- North arrow
- Scale
- Map data and symbols
- Overview map

For the general overview of the location of the whole region there is added an overview map in the top left corner which shows where the area is located in Finland exactly. For this, just the region around the end of the Gulf of Bothnia was chosen, with Oulu as a benchmark for easier orientation. A map of whole Finland was intentionally not used, because on the one hand it would be too large to mark the area in a senseful way, and on the other hand it seemed to be more practically to focus more on a specific part of Finland to show the location, since the overview map should not be the main focus on the wind park map and represent just a support.

The location of the map is clearly shown, and one can easily see where the wind park itself is located. The scale size was selected to be 1:50.000, which shows the immediate surroundings of the wind park, but one can still clearly see the location of the wind turbines and all the service roads etc.

The aim of the legend was to show only the most important features what one need to be able to interpret the map. In color selection the distinctiveness has been tried to take account so the symbols of the map would be clear to interpret.

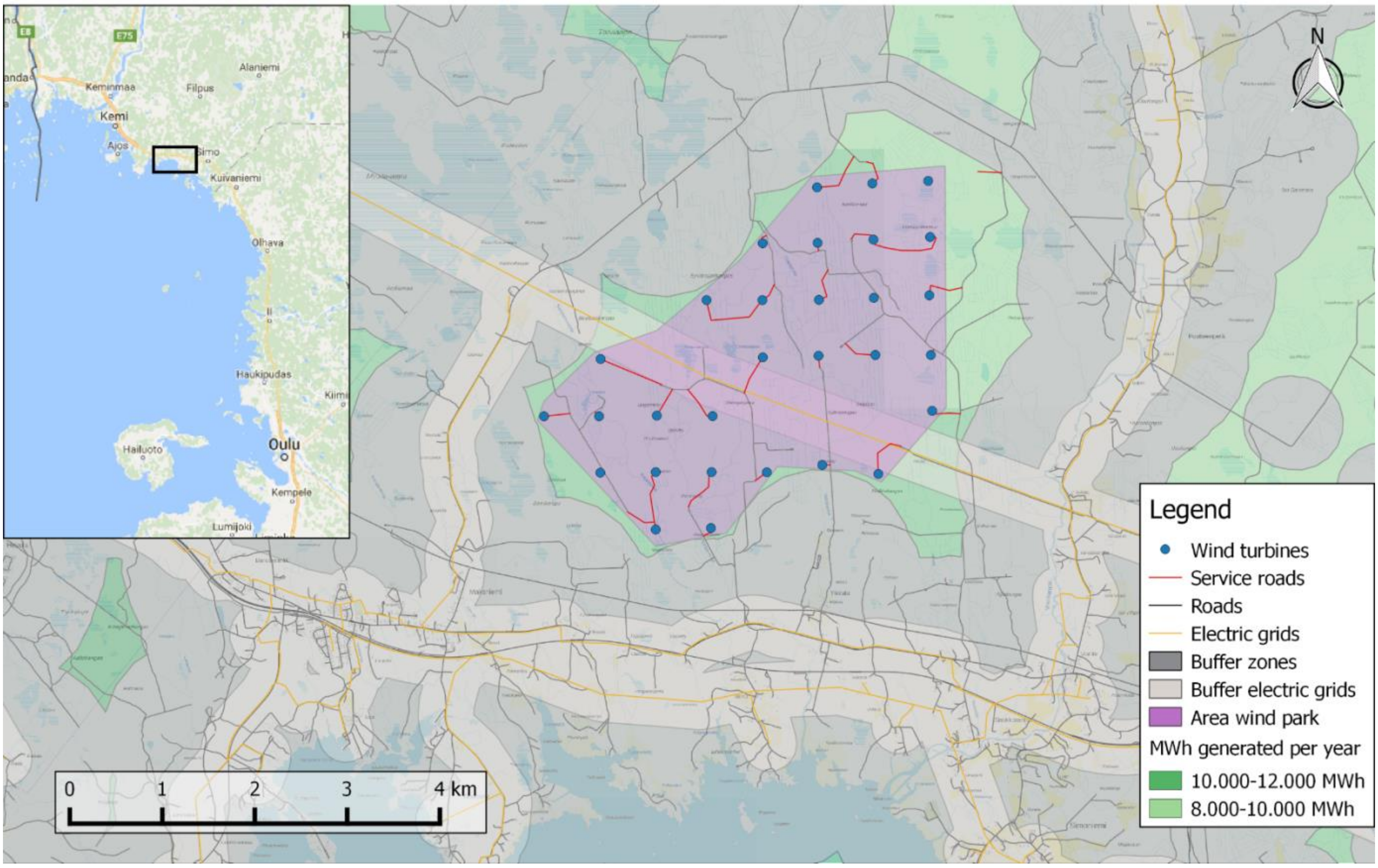
For wind data, the same choropleth scale has been used than in the original source (FMI, 2008). To avoid confusion about reading the generated wind power just two green shades where chosen, since the map contains only two categories of different wind power generated of importance (and not the whole range as defined in the Finnish Wind Atlas).

Obviously, the aesthetics of the map could probably always be better and for more simplicity the two buffer zones merged into one, but overall one could say this is a successful map. It will tell all the relevant information and but still contains enough simplicity for one to interpret it.

Appendix: Map wind park “Pikku Berliini”

Wind park Pikku Berliini

Map data: National Land Survey Finland, Finnish Environment Institute, Finnish Metereological Institute, Google Maps; Map created by: Ap Anttila, Khanh Dao, Marcel Schepers [autumn 2017]



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