

REM Wind Energy Inc., Consulting Division
Proposal: Construction of 3 New Wind Farm Projects in the Peace Region, BC
Meteorological Assessment of Each Site

Project summary: REM Wind Energy Inc. has received approval to establish three new wind farms in the Peace Region of northeastern BC. Current development plans are pending one final assessment by a wind-energy consultant, hired by the company to determine the advantages and disadvantages of establishing wind farms at each location. This report summarizes their findings.

Section 1: Wind Energy Generation. Modern wind turbines use the kinetic energy of the wind for the generation of electrical energy. As the wind passes through the blades, the aerodynamic lift causes the rotation of the blades, which, in turn, rotates the generator for the production of electrical energy.

The main parts of a modern wind turbine include the blades, the hub, the nacelle, the gearbox, the generator, the tower, and the control system. The blades rotate due to the lift of the wind, and the rotation occurs about the central hub of the wind turbine. Inside the nacelle, the gearbox and the generator convert the rotational motion into electrical energy. Finally, the tower supports the wind turbine at a height of about 80 meters or more, where the wind speed is high due to the vertical profile of the wind, which increases the speed of the wind because of the decrease in friction force.

Two useful tools for the determination of the wind speed and the wind power available are the wind climatology maps and the topographic maps. Wind climatology maps provide the average wind speed and the density of the available wind power at a height of about 80 meters, which is the height of the hub of the wind turbine. Topographic maps provide information about the features of the landscape, including the location of mountains, ridges, and valleys, which affect the wind speed, acceleration, and turbulence.

Section 2: Impact of Wind Turbines on Local Air Flow. Large-scale wind farms have the potential for altering the boundary layer of the atmosphere because of the kinetic energy extracted from the airflow by the wind turbines. As the wind passes through the turbines, the momentum of the wind is extracted

by the rotating blades of the turbines. This leads to a reduction of the speed of the wind and the formation of turbulent wakes behind the individual turbines.

If the differences in the surface heat flux are not considered, the main impact of the wind farm on the incoming airflow will be the reduction of the speed of the wind and the increase of the turbulence of the incoming airflow through the wind farm. This occurs because the wind turbines, being a series of obstacles, extract the momentum of the incoming airflow, leading to the increase of the turbulence of the airflow through the wind farm.

A useful model for diagnosing the impact of the wind farm on the incoming airflow will be a computational fluid dynamics (CFD) model or a mesoscale model of the atmosphere, which can be used for simulating the wind and the turbulence of the airflow through the boundary layer of the atmosphere.

A useful map for diagnosing the impact of the wind farm on the incoming airflow will not be a wind climatology map because such a map can only be used for displaying the average wind speed over a period of time.

Section 3: Site A – Wind Farm Downwind of Local Peak. Site A is situated in the northwest part of Hudson's Hope. Moreover, this site is situated in the downwind direction from the elongated mountain ridge. Since the general direction of the wind in this area is from the west, the wind is forced to move over the mountain ridge before reaching the site. When the wind passes over the mountainous terrain, it accelerates over the mountain ridge and continues to descend on the other side due to the effect of the pressure gradient and gravity flow.

As the wind descends over the mountain ridge, it may produce mountain wake effects that could lead to unpredictable winds and produce turbulent eddies. According to the wind speed map in Step 4, the average wind speeds at Site A vary from 4-5 m/s with moderate wind power potential.

The advantages of building a wind farm at Site A include the possibility that the wind speed may increase due to the acceleration effect over the mountain ridge. On the other hand, one disadvantage of this site is the effect on the efficiency and stress on the wind turbine.

Section 4: Site B – Wind Farm in a Valley. Site B is situated in a valley between two mountain peaks, located west-southwest of Chetwynd. Valleys are usually protected from the effects of the prevailing winds, which are blocked by the surrounding mountains, preventing large-scale airflow through the area. Therefore, the average wind speed in a valley is generally slower and more irregular compared to other areas.

On the other hand, valley channeling can sometimes be experienced, depending on the weather conditions, where the wind speed increases through the gaps between the ranges of the mountains. Nevertheless, based on the wind speed map provided for Step 4, the average wind speed at Site B ranges from 3-4 m/s, the slowest among the three sites, and has the lowest wind power potential.

A positive attribute of Site B is the possibility of the wind speed being higher due to valley channeling, where the air passes through the valley gap between the ranges of the mountains. On the other hand, the main disadvantage of Site B is the presence of the surrounding mountains, which block the prevailing winds, resulting in slower average wind speeds and lower wind power potential, making the location the worst among the three sites for the production of wind energy.

Section 5: Site C – Wind Farm near a Local Mountain Peak. Site C is found southeast of Hudson's Hope, on an exposed and flattened ridgetop. This means that the site is exposed to the prevailing westerly winds, and the airflow can pass across the ridgetop with relatively little interference.

It should be noted that the ridgetop might experience stronger winds compared to the valleys, as the airflow might accelerate as it passes over the ridgetop. This would ensure unobstructed airflow, unlike the valleys. From the wind speed map created in Step 4, Site C has the highest wind speeds at 5–6 m/s, as well as the highest wind power potential among the three sites.

It should be noted that the wind power generated increases with the cube of the wind speed. Therefore, a slight increase in the wind speed at Site C compared to the other sites would ensure greater wind power generation. Another advantage of Site C is that the exposed ridgetop ensures stronger and unobstructed airflow, thereby ensuring greater wind power density.

Another possible disadvantage of Site C might be that the exposed ridgetop might experience gusty winds at times, depending on the synoptic weather patterns. However, this might not be a problem compared to the turbulent winds that might be experienced in the mountainous terrain.

From the available wind speed data, the wind power potential maps, and the terrain analysis, it can be concluded that Site C offers the best conditions for the development of wind power in the Peace Region.