Site Suitability Analysis for Solar and Wind Farms in The West Kootenay

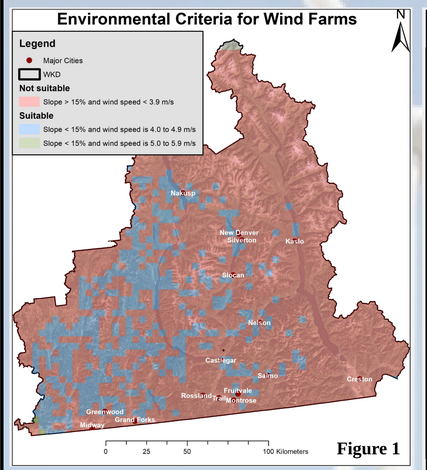

Figure 1

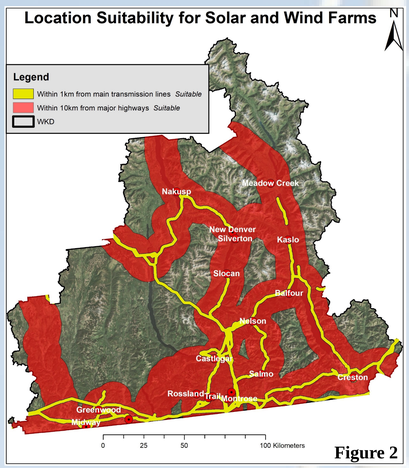

Figure 2

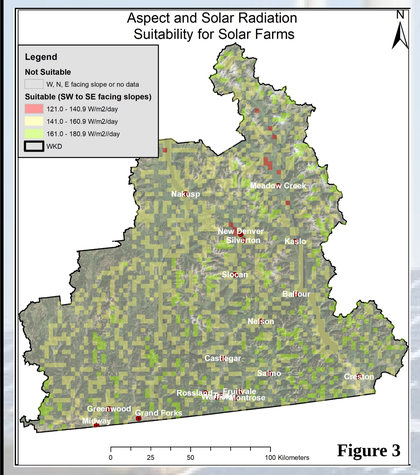

Figure 3

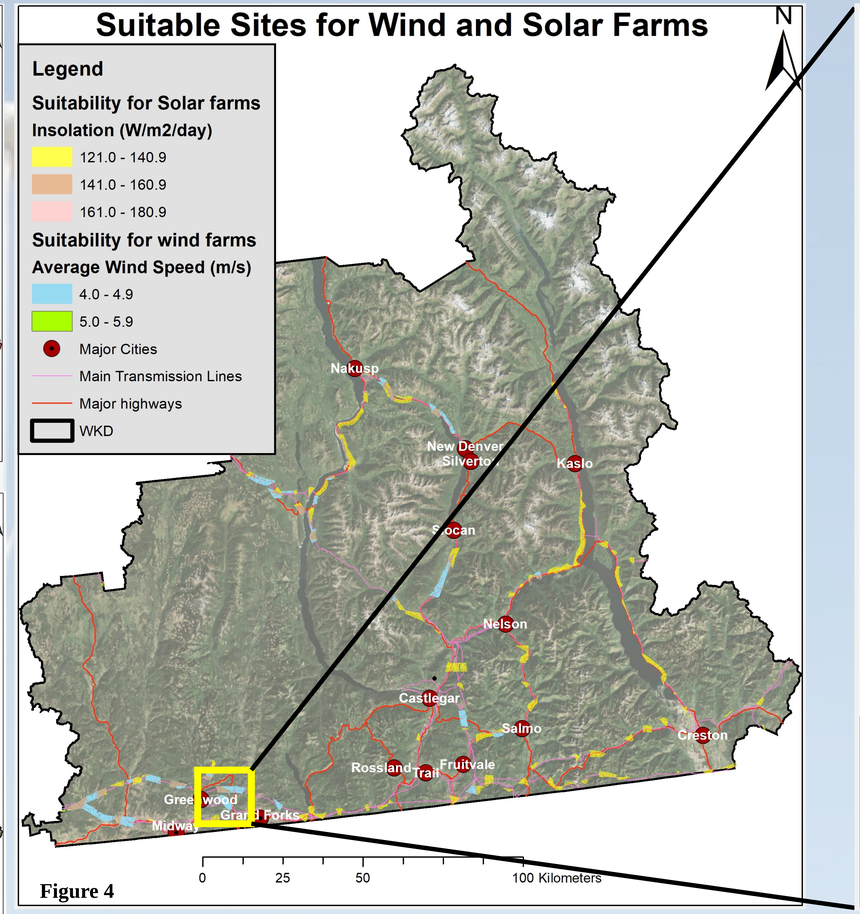

Figure 4

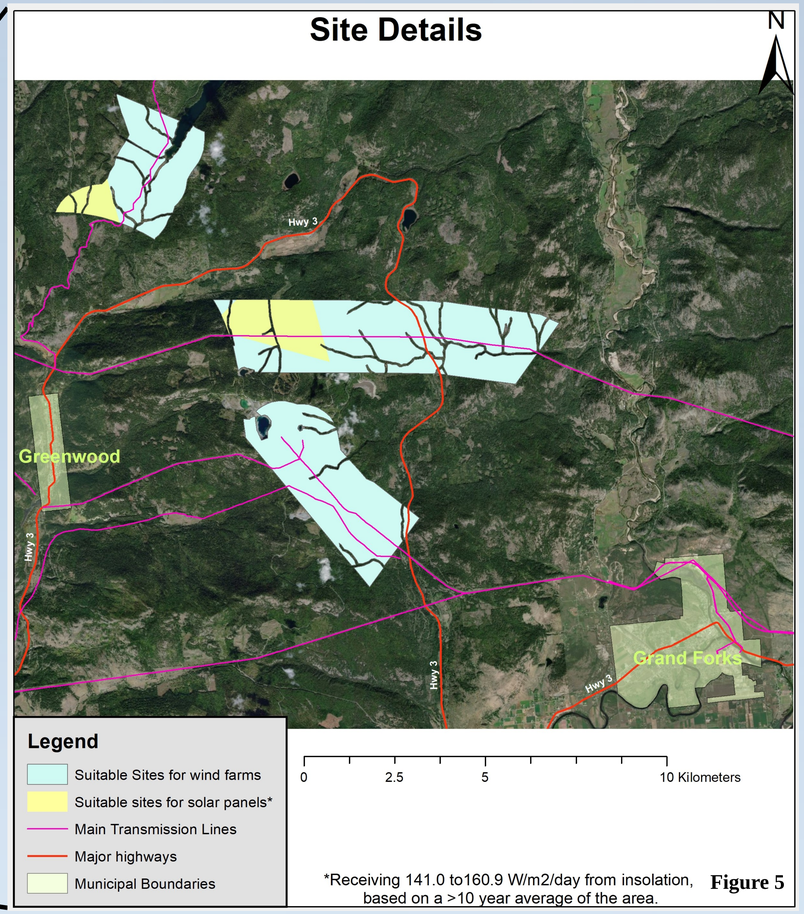

Figure 5

Table 1

	Insolation ($W/m^2/day$)	Suitable Areas (km^2)	% of Total WKD area	Solar Panel Efficiency	Average GWh / year	Households powered / year
Solar	121.0 - 140.9	3.67	0.01%	15.0%	1.10	102
	141.0 - 160.9	352.25	1.12%	15.0%	121.30	11,231
	161.0 - 180.9	50.54	0.16%	15.0%	19.71	1,825
	Total:	406.46	1.29%		142.11	13,158

	Wind speed (m/s)	Suitable Areas (km^2)	% of Total WKD area	Turbines / km^2	Average GWh / year	Households powered / year
Wind	4.0 - 4.9	232.00	0.74%	1	233.72	21,640.44
	5.0 - 5.9	3.00	0.01%	1	6.41	593.73
	Total:	235.00	0.75%		240.13	22,234.18
Grand Total:		641.46	2.04%		382.24	35,392.19

Introduction:

Fossil and carbon-based fuels have helped mankind develop its society and create a globalized world. However, it is well known today that the use of these fuels has led our environment to multiple crises, including climate change, air and water pollution and the threat of mass extinction, not to mention what may happen to our society when oil reserves have been depleted. For this reason, society and the economy must start phasing-out of fossil fuels and slowly begin to adapt to new, sustainable and renewable sources of energy.

Many initiatives and projects around the world have embraced this goal and have begun a transition already. In our region, the West Kootenay District (WKD), the West Kootenay EcoSociety has started a petition to ensure that local municipalities commit to a transition to a 100% renewable energy source economy. This initiative poses many challenges, some of which this project intends to address, specifically finding suitable sites within the WKD for the implementation of renewable energy technologies, such as wind turbines and solar panels.

Methodology:

All maps and data analysis were performed using the Esri ArcGIS version 10.6.1 software and the methods were as follows:

1. Data research regarding annual average wind speed (measured 80m off the ground for 43 years) and solar radiation ($W/m^2/day$) in the WKD, environmental criteria for suitable areas, such as maximum slope of 15% for wind farms and SW to SE facing slopes for solar farms.
2. Establishing client's criteria and applicable regulations, defined as: 30 meter buffer zone from lakes and streams and within 10 kilometers of major highways; 5 kilometers away of major municipalities to minimize noise problems and within 1 kilometer of major transmission lines.
3. Researching best available wind turbines and solar panels technologies such as:
   a) Wind turbine: Cut in wind speed (minimum wind speed): 4 m/s, Cut out wind speed (maximum): 25 m/s. Hub height (tower): 65 to 78m, Minimum distance between turbines: 500m (1 turbine/km^2).
   b) Solar Panels: Efficiency: 15%, no other applicable parameter was established.
4. Creating a raster layer of intercepted areas between suitable wind speeds and suitable slope areas, transforming it into a polygon layer. (Figure 1)
5. Creating a polygon layer for the client's criteria and applicable legislation. (Figure 2)
6. Creating a polygon layer of intercepted areas between layers from step 4 and 5.(Figure 3)
7. Creating a raster layer of intercepted areas between suitable areas for solar panels (SW to SE facing slopes) and solar radiation, transforming it into a polygon layer.
8. Creating a polygon layer of intercepted areas between layers from step 6 and 7.

Results and Discussion:

The results show that there is a great amount of land in the WKD suitable for both wind and solar farms. The figures for each individual energy source are 235km^2 of land suitable for wind farms and 406.5 km^2 for solar farms, totalizing 641.5 km^2 or 2.04% of WKD's total area. Utilizing the best technologies available, the combined power generation of all areas range from 263.3 GWh/year to 501.2 GWh/year. Based on energy consumption of 900 kWh/month (9.0 x 10^{-4} GWh) per household, the number of households that can benefit from renewable energy range between 24,380 to 46,405 per year. The complete results can be seen in the final map (Figure 4) and in detail on Figure 5 and on Table 1

Comparing the efficiency between the two technologies, results show that the use of wind turbines is approximately 292% more efficient, generating 1.02 MWh/km^2/year while solar panels only yield 0.35 MWh/km^2/year.

Although the highest power output is ideal, it is not possible to reach these numbers given the fact that some suitable areas for wind farms are also suitable areas for solar farms, even though it is possible to have both technologies on the same site, it is not possible to cover 100% of the same area with both technologies. However, any renewable energy source implemented will contribute to diminishing CO_2 emissions from non-renewable power generating sources, which can help reduce the effects of climate change. Another positive impact is the promotion of the renewable energy industries, which can facilitate the access of renewable energy technology at a lower cost.

Limitations and Assumptions:

Reclassifying data and raster may be subject to interpretation and not as accurate as original data. Also, sun radiation and wind speed numbers, when extrapolated in calculations of power generation (e.g. calculating annual average power output), might have a great discrepancy from reality due to the accuracy of its measurements, technology used to generate the power and the fact that figures from environmental factors can vary drastically from year to year. Other limitations to this study include wind blocked and shadows cast by man-made structures, costs of renewable technologies and exact figures of energy consumption and households existent in the WKD. Furthermore, due to time availability and budget restrictions, this project does not cover environmental impacts caused by the implementation of these technologies on each site versus the benefit they would bring.

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Data Sources:
Selkirk College database, Wind Atlas, Government of Canada, iMapBC, IRENA (International Renewable Energy Agency).

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