

Verification of Simulated Wind Power Production in Québec

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the **PEMBINA**
t i n s t i t u t e 

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About the Author

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The Pembina Institute creates sustainable energy solutions through research, education and advocacy. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses. The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy, and environmental governance. More information about the Pembina Institute is available at www.pembina.org or by contacting: info@pembina.org

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1 Introduction

1.1 Context of Simulation

The current analysis was completed in order to verify the assumptions that were made to simulated the hourly output from future wind power plants in the province of Québec.

The author's mandate was to examine two specific data sets and confirm that the assumptions made within these data sets were reasonable without re-creating either unless the aforementioned assumptions warranted re-calculation.

Specifically the author's mandate included:

- a) Obtenir, dans la mesure du possible, des données réelles obtenues dans des campagnes de mesure de vent sur différents sites distribués sur le territoire du Québec.
- b) Simuler, sur la base de ces données, la production horaire de parcs éoliens distribués sur le territoire du Québec.
- c) Sans refaire l'étude, valider la méthodologie utilisée par Hélimax pour générer une chronique de 36 ans de production horaire pour les parcs éoliens du premier appel d'offres.

Section 2 contains the analysis of the Hélimax study entitled Reconstitution de Séries Historiques de Production Éolienne; Parcs éoliens de la Gaspésie (990 MW) referred to in item c).

Section 3 of this report encompasses items a) and b). Wind data from prospective developers was not available, however on the basis of a confidentiality agreement covering their identity and data, developers made simulated production data available for five proposed wind farms in Québec. The methodology used to create this data set was reviewed as opposed to creating such a data set from raw wind data.

2 Review of HéliMAX Data

2.1 Assumption Review

The methodology used by HéliMAX in their February 2008 report entitled “Reconstitution de Séries Historiques de Production Éolienne; Parc éoliens de la Gaspésie (990 MW)” prepared for Hydro-Québec Distribution was reviewed as well as the hourly data. This report backcasts the production of the 990 MW of wind power to be developed in the Gaspésie for the years 1971 and 2006.

The data were collected from Environment Canada monitoring stations, weather balloon data, as well as wind masts stationed at the locations of the 990 MW of wind power to be built in the Gaspésie. Available data diminishes the further back in time as wind monitoring is more common and available today than it was in 1971.

In order to get a common set of assumptions for the entire period the aforementioned data were input into CALMET, a wind-field model used to generate three-dimensional meteorological fields, also a program that is commonly used to model wind regimes, and were calibrated to known data at 80 m heights that is monitored on the development sites.

Production was simulated using the power curve for GE sle 1.5 MW wind turbines using the software package “WindFarm” developed by ReSoft, a software package that is common within the wind energy industry. Assuming several losses including icing, aerodynamic degradation, line losses as well as cold weather stops and maintenance.

The author reviewed the simulated data, and checked for general trends and specific known down times such as extreme cold weather events. In my opinion the methodology is rigorous and appropriate to backcast the production of the 990 MW of wind energy.

2.2 2004 Comparison

The author completed a similar study in 2005 based on 2004 wind data for the proposed 990 MW of wind developed in the Gaspésie.¹ This study was less rigorous than that of HéliMAX, as it used fewer wind data sets, a simpler geographic dispersion of the wind farms and a smoothed power curve to simulate the production from the farms as opposed to a complete “WindFarm” model.

Nonetheless, the two data sets correlate well, with an R^2 value of 0.7. As would be expected from the assumptions made in each methodology, the HéliMAX data is more detailed, but both simulations show the same general trends, including times of peak production and minimum production as can be seen in Figure 1. It should be noted that extreme temperature events (below -30°C) were not simulated in the author’s 2005 data set.

¹ http://www.regie-energie.qc.ca/audiences/3595-06/APLNQL3595/B-19-APNQL_RappExpert-Weis_3595_28aout06.pdf

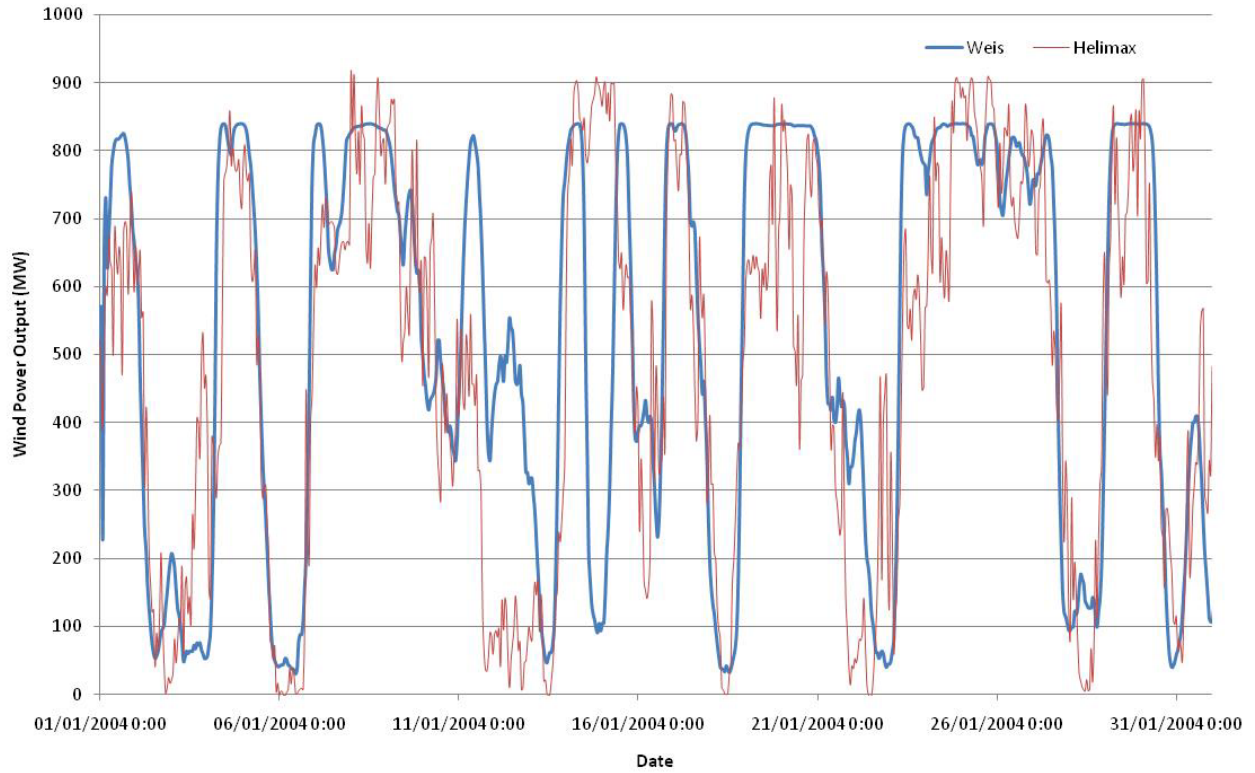


Figure 1: Comparison of January 2004 data points

3 Review of Proposed Wind Farm Production

3.1 Simulation Review

Simulated production data was provided for 5 proposed wind farms in Québec. As was stated in the introduction, for business competitiveness reasons raw wind data was not provided.

However, simulated production data from the individual farms as well as the aggregated output of these farms were provided under a confidentiality agreement. The sample data set was created using actual wind data between October 1, 2006 and September 30, 2007. Based on information provided by the developers, the assumptions that were made in order to compile this simulation are listed below:

These assumptions include:

- A General Electric “GE sle 1.5 MW” wind turbine was used, and an adjusted power curve was created for each site to represent its special distribution and wake losses.
- Wind data was collected for each proposed wind farm and projected from 50 m or 60 m (depending on the physical height of the tower at that location) to an 80 m hub height.
- Missing data due to icing, data corruption or mast failures were interpolated using local towers.
- A single wind mast data set was used to represent the output of the entire farm. Each site has 3 or 4 masts and the “most representative” tower was selected, based on the judgment of the developer and the proposed layout of the wind farm.
- Turbine output was adjusted for the average annual air density based on the sites’ average annual air pressure and temperature. This tends to overestimate production in the summer and underestimate in the winter, by up to 10% in both cases.
- 3% downtime was estimated and was spread across the final output of the farms.
- 2% production losses were assumed in the winter due to ice accretion.
- Wind farms cease to produce power when the temperatures drop below -30°C and return to service at -25°C .

The assumptions that were made are reasonable to simulate the expected output of the proposed wind farms and are, in the opinion of the author somewhat conservative. Using the average annual air density calculation as opposed to an hour by hour adjustment is the largest simplification in terms of hourly performance. Also, the icing losses are likely overestimated as the downtime estimate likely incorporates some or all of the icing events. In the worst case scenario the conservative estimates are likely on the order of 10% in the coldest winter months.

The results suggest an anticipated capacity factor of approximately 29%. This is consistent with wind farms in much of Canada.

For comparative purposes the author completed a similar analysis to that done in similar study in 2005 based on 2004 wind data for the proposed 990 MW of wind developed in the Gaspésie.² This involved collecting the Environment Canada wind data from the Sept-Iles station (Climate ID: 7047910, Lat: 50° 13.2N, Long: 66°16.2W, Elevation 54.9 m) for the same time period. Using a smoothed power curve for a wind farm of GE sle 1.5 MW turbines, the output was simulated and found to be similar to that of one of the five data sets that was provided in terms of capacity factor, standard deviation and relative maxima and minima.

Therefore, in the opinion of the author, the developers' data set is based on reasonable assumptions to illustrate the output and trends that the proposed wind farms would have produced had they been in operation between October 1, 2006 and September 30, 2007.

² http://www.regie-energie.qc.ca/audiences/3595-06/APLNQL3595/B-19-APNQL_RappExpert-Weis_3595_28aout06.pdf