2025 WIND ENERGY PROSPECTS
A REALISTIC POSSIBILITY FOR QUEBEC

Technical Opinion
For
The Canadian Wind Energy Association

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September 2010
1. **INTRODUCTION AND MANDATE**

In publishing *WindVision 2025*, the Canadian Wind Energy Association (CanWEA) has put forward an innovative new vision for the future of wind energy in Canada. CanWEA believes that for Canada to become a worldwide leader in wind energy, it must aim to obtain at least 20% of its electricity from wind energy by 2025.

A number of initiatives have been launched nationwide to demonstrate that this bold vision is not only achievable from a technical point of view, but also that there are solid economic and environmental arguments in favour of making wind power a Canadian priority. This technical opinion is in line with regional Canadian studies aimed at informing decision-makers and other Canadians about the following specific question:

*Is it conceivable to add 8,000 MW of wind energy to Hydro-Québec’s power generation system by 2025? The addition of 8,000 MW of wind energy to the grid would take place over a 10-year period beginning in 2015. Since the existing generation mix in Quebec will already include 4,000 MW of wind energy by 2015, the total wind power capacity installed in Quebec would be approximately 12,000 MW 10 years later, which represents just over 20% of the province’s total generation mix. The percentage of wind power supplied by wind farms would increase from 4.5% in 2015 to 13.5% in 2025.*

The Government of Quebec’s 2006 Energy Strategy is on track to install 4,000 MW of wind energy, which will represent just under 10% of the total capacity of Hydro-Québec’s power generation system (including electricity from the Churchill Falls station in Labrador), between now and 2015. The experience shows that wind energy meets most of the physical (site quality), technical (ease of grid integration), environmental, social, legal and economic factors and constraints.

Not only has wind energy had a significant impact on Quebec’s energy profile, but government policy has made the creation of a Quebec wind energy industry possible, in both the production and service sectors. The Quebec government’s 2006 Energy Strategy does not include any significant policies for additional procurement post 2015. However, the government has issued a specific policy for the development of hydroelectricity. It is therefore relevant to examine a new wind energy policy that would be in line with the energy context from 2015-2025.

What will wind energy’s maximum contribution be under these circumstances?

The question becomes moot once optimal competitive conditions are in place. If wind power is competitive, the INRS\(^1\) and RSW Inc.\(^2\) studies produced for the 2005 *Commission parlementaire*

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\(^1\) See the expert report by Gaëtan Lafrance, *Energy Security and Wind Power*, Expert opinion presented to the Minister of Natural Resources, Wildlife and Parks, November 2004, available from: https://www.mrnf.gouv.qc.ca/english/publications/energy/strategy-lafrance.pdf [This is an English translation of the original report]

\(^2\) See the RSW report revised in June 2005, www.MRNF.gouv.qc.ca.
sur la sécurité et l’avenir énergétiques du Québec [National Assembly Committee on energy security and the energy future for Quebec] showed that the 10% of grid capacity figure could be exceeded. However, the authors stated that these advances merit additional analysis and confirmation of real value from the wind energy sector. It is important to recognize that real-time operational management of an electrical grid has its own constraints. While wind power is a promising option, the grid operator cannot assess a large-scale integration of the sector without validating that the sector meets all of its operating criteria.

Given the time allotted for producing this opinion, the methodology is not exhaustive. It is also impossible to cover all of the technical, physical, social and environmental aspects related to optimal wind energy development. This opinion is limited to the technical feasibility into the integration of large amounts of wind energy into the Hydro-Québec electrical grid.

The analysis of wind energy penetration into an electrical grid is not conducted with simple calculations. It is important to remember that operational practices, as well as energy forecast and equipment planning models, take into account a number of planning horizons: from now and into the future. To establish the anticipated reference scenario for 2015-2025, we are relying on Hydro-Québec’s 2009 Strategic Plan3 and the Quebec government’s 2006 Energy Strategy4.

The discussion examines two scenarios: a) medium-term planning based on management of the Hydro-Québec grid reservoirs and the characteristics of the grid’s production, transmission and distribution equipment, and b) the grid’s short-term stability and reliability constraints.

Numerous initiatives enable us to assess the likelihood of achieving a more ambitious goal in the wind energy sector. These initiatives can be placed into one of two categories: 1) work by INRS-IREQ and RSW Inc. that led to the recommendation to install 4,000 MW on the grid during the 2005 National Assembly Committee, 2) work by Hydro-Québec over the past three years that can be accessed from the Régie de l’énergie website5.

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Main conclusions

5.3 Technical feasibility of an additional 8,000 MW of wind energy

For demonstration purposes, we have established an alternative scenario to the reference case identified in section 1. The general hypotheses retained for this comparison are as follows:

- The electricity needs to be supplied by Hydro-Québec correspond to the 2009 Strategic Plan for the 2017 planning horizon and an extrapolation based on the overview for the 2025 planning horizon. This is a business-as-usual scenario that does not include any special electricity policies (see Graphs 1 and 2 for more information).

- Quebec would like to add 8,000 MW of wind energy at the rate of 800 MW per year beginning in 2016; in 2025, total wind energy capacity would therefore be 12,000 MW.

- In terms of hydropower, the La Romaine project (1,550 MW) will be complete. The additional 3,000 MW of hydroelectricity initiatives set out in the 2006 Energy Strategy will be completed after 2025 based on demand. This is a worst-case scenario for wind energy since there is reduced hydroelectric capacity to provide balancing reserves for the wind energy capacity in service.

- After 2017, the only new facilities that would be launched by Hydro-Québec are those relating to the wind energy tenders. In practice, this means that this new wind energy will serve both the Quebec and export markets.

- The reserve rate is 14% and the capacity factor (CF) of wind energy is assumed to be 35%. This CF is based on technological improvements leading to higher performance after 2015 and wind farms will, in part, be located in areas where the wind resource is high. We also assume that future wind turbines will not be constrained by extremely low temperatures.

Table 1 presents the reference scenario for energy needs. Table 2 presents Hydro-Québec’s supply plan for Quebec demand, as well as anticipated energy production surpluses for new or export markets. Table 3 describes the impact of developing an additional 8,000 MW of wind energy by 2025.

The primary results of these hypotheses for the 2025 planning horizon are as follows:

- Wind energy will account for 13.5% of the energy produced by Hydro-Québec (Table 3). Wind energy will account for approximately 20% of the total installed capacity of the Hydro-Québec system (Table 4).

- In the reference case scenario (hydro without wind energy after 2015), the margin of system flexibility is approximately 44 TWh.
• In a wind energy scenario in which Hydro-Québec Distribution meets its additional needs with wind power, Hydro-Québec’s margin of flexibility for exports would be approximately 52 TWh.

• In a wind energy scenario, the margin of flexibility for hydropower would be approximately 28 TWh, which is more than sufficient to meet the reserve capacity required by the NPCC.

This concludes the discussion on technical feasibility. In fact, the question becomes moot if the necessary measures are taken to ensure grid safety and reliability. With the new addition of hydro capacity such as La Romaine, Hydro-Québec already has a sufficient surplus to meet the mandated 14% reserve rate, or 1,140 MW. This new wind energy capacity will further add to existing surpluses. The problem is therefore largely resolved in how these surpluses are managed.

With regard to medium-term planning and management of grid facilities such as reservoirs, what would an additional 8,000 MW of wind power mean? Although the context is different, our pre-2005 simulations still holds true. Despite this, it would be necessary to carry out simulations using the new grid values. The situation is more encouraging for the issues that seemed critical to us at the time:

a) Even without taking into account new wind energy, capacity satisfies Hydro-Québec’s requirements, which include the La Romaine project. With the additional wind power, the demand curve is modified since wind power is an inverse demand. Hour by hour, demand is therefore less than or equal to the demand established in the scenario without wind energy. We therefore have the necessary resources to meet demand in both scenarios.

b) The capacity supplied by the wind turbines combined with those that are “must run” could exceed internal and external demand. Having one part of the wind farm go offline then becomes an economic issue rather than a technical one.

c) In terms of diversions, it would be necessary to re-run the simulations to take into account additional overcapacity in some reservoirs, such as the Rupert River diversion; however, intuitively this is not a problem if wind farms are geographically spread across the province and the variable nature of the energy production from these wind farms is therefore smoothed.

d) In terms of transmission capacity, it would be important to assess power flow based on the location of the wind farms in the province. Once again, this problem is no more serious than that of adding new hydro capacity, e.g. with a river diversion or catchment basin. The issue of whether or not to add transmission capacity exists, regardless of the source of energy being planned. However, in the context of exports, one of the benefits of wind energy is that it complements hydro based power, both in terms of its contributions and green market opportunities.
It is possible to integrate 8,000 MW of additional wind energy capacity into the Quebec grid without compromising grid safety. In light of Hydro-Québec Distribution’s experience and the studies conducted after the first wind farms began to operate following the 1,000-MW tenders, as well as the analyses conducted as part of this document, there were no factors uncovered that would prevent Hydro-Québec Distribution from pursuing wind energy development beyond the 4,000 MW already under contract that would jeopardize the safety of the grid. In addition, the studies filed by Hydro-Québec Distribution with the Régie de l’énergie do not suggest any excessive impact on the resources required by Hydro-Québec Production to ensure the equalization of wind energy production.

Adding this level of production capacity should undoubtedly be accompanied by investments in grid transmission and reinforcements, as is the case for all major additions of new energy production capacity. In addition, it would be necessary to identify new markets to which the energy surpluses could be sold, which is already part of the Government of Quebec’s Energy Strategy.

In conclusion, diversifying electricity production sources in favour of additional wind energy appears to be an imminently promising alternative moving forward.