CANADA

Looking North for Solutions

Canadian wind energy is integral to North American transition to a clean-energy economy.

By Jean-François Nolet

For years, Canada's wind-energy industry has had the potential to expand its market through exports to the United States, but it is only now — bolstered by a perfect storm of supply-and-demand drivers — that the opportunity is finally becoming concrete.

On the U.S. side of the border, state governments and electricity distributors are grappling with the multifaceted challenge of meeting ever-more stringent renewable-energy targets, responding to federal efforts to cut power-plant emissions, and navigating the looming retirement of tens of thousands of megawatts of aging coal and nuclear facilities. Increasingly, they are seeing clean-power exports from Canada as a reliable and cost-effective solution.

The Massachusetts Omnibus Energy Bill is a case in point. The state is looking to Canadian hydroelectricity imports, or hydro, in tandem with onshore wind or other renewable technologies, for as much as 12 TWh of new electricity supply. Its neighboring state, New York, plans to reach 50 percent renewable energy by 2030 and also will need large amounts of clean electricity from Canada.

MEETING THE TARGET

The Obama Administration's Clean Power Plan (CPP), which aims to slash carbon emissions from the U.S. power sector by 32 percent from 1990 levels over the next 15 years, identifies clean-energy exports from Canada as a viable way for states to meet that target. And many will make that choice.

The North American Electric Reliability Corporation (NERC) predicts that, as the plan comes into effect, Canada-U.S. exports will triple. Whether the CPP survives court challenges and November's presidential election remains to be seen, but whatever happens, it is clear U.S. commitments under the Paris Agreement will eventually require it to act to clean up its coal-heavy grid.

It's not surprising that U.S. states are looking north for solutions.

Meeting aggressive targets from in-state wind and solar will be a challenge, especially in the densely populated U.S. Northeast. Siting projects can be difficult; permitting costs are high, and the grid needs additional tools and options to absorb new influxes of variable generation. Coastal states are eyeing offshore wind as a way to meet their clean-energy needs, but that brings a whole other set of issues, ranging from cost to social acceptance.

Canada, meanwhile, produces more than 80 percent of its electricity from emissions-free generating sources, and it already exports about 10 percent of its output to U.S. customers. While the overwhelming majority of that power comes from Canada's vast complex of hydro reservoirs, there is growing recognition on the Canadian side of the border of the advantages of bringing wind energy into the mix.

A BUNDLED PRODUCT

Major players like Emera and Hydro-Québec are talking about using hydro to back variable sources of generation like wind and delivering a bundled product to their U.S. customers.

In Hydro-Québec's case, the utility is testing the waters by teaming with

The 62 MW Glen Dhu Wind Farm in Nova Scotia, Canada.

Chicago-based Invenergy LLC and developers of the proposed Vermont Green Line transmission project in a bid to supply 400 MW of clean energy to Rhode Island, Connecticut, and Massachusetts. Under the proposal, Québec hydro would supplement the output of Invenergy's planned Bull Run wind project in northern New York to ensure a firm block of power is delivered 24 hours a day, seven days a week.

The results of the New England Clean Energy request for proposals (RFP) have yet to be announced, but the Québec government already is running with the concept. Its new long-term energy strategy not only looks to boost exports overall, but it also specifically targets the construction of wind farms in Québec as part of the plan.

ALSO IN THIS SECTION

The 198 MW Wolfe Island Wind Facility in Ontario, Canada.

There are a number of reasons why a wind-hydro bundled product makes sense.

WIND COSTS DROPPING

First, the cost of wind energy has dropped dramatically, falling 61 percent in the past six years alone. Hydro-Québec's most recent wind-energy request for proposals ended in the utility paying just 6.3 cents/kWh for the output of three projects totaling 446 MW. When you take 6.3 cents/kWh wind and combine it with low-cost heritage hydro, it becomes interesting for potential buyers, especially when you consider those prices are in Canadian cents.

A wind-hydro hybrid is also better positioned to meet the requirements of prospective customers who want a green product.

Wind is considered a renewable energy source in most of the U.S., and large hydro is often not. Being sensitive to this difference not only expands the market opportunity for Canadian suppliers, but also pays additional dividends. New York and the New England states may allow large hydro to meet a portion of their clean-energy targets, but unlike wind, hydro does not qualify for potentially lucrative renewable energy credits in those markets.

The bottom line is if Canadian utilities don't incorporate wind into their export product, it represents a lost economic opportunity.

BUILT FOR NEED

Finally, taking advantage of new markets for clean electricity will require building new generation to meet the demand. On that front, wind energy's advantages are clear. Wind-generating capacity can be built incrementally in line with need, and it can be deployed quickly. If permits were started on a new large hydro project today, it would not be built for 15-20 years. Most importantly, however, wind energy is less expensive than any new large hydroelectric project now on the drawing board in Canada.

A new study, sponsored by the Canadian Wind Energy Association (CanWEA) and conducted by an expert team led by GE Energy Consulting, underscores the critical role Canadian wind can play in North America's transition to a clean-energy economy.

The Pan-Canadian Wind Integration Study (PCWIS) examined four cross-Canada development scenarios and found no operational barriers to achieving a 35 percent wind penetration by 2025.

Managing that level of wind on the grid depends heavily on the free flow of electricity across jurisdictions, not just between provinces in Canada, but also across the border with the U.S. It would require 10 GW of new transmission connections between markets, but given that wind would displace more expensive coal- and gas-fired generation in both Canada and the U.S., the operating cost savings would pay for the $3.7 billion capital cost of those lines in just three years.

INCREASED EXPORTS

The opportunity for Canada to economically benefit from increased exports is significant.

For every 1 MWh of additional wind generation produced in Canada, the analysis found that electricity exports from Canada would increase by 0.5 MWh.

From an environmental aspect, benefits would accrue on both sides of the border. At a 35 percent wind-penetration level, Canada would see 32.3 million metric tons of greenhouse gas reductions, while emissions on the more fossil-dependent U.S. grid

The 198 MW Wolfe Island Wind Facility in Ontario, Canada.

would fall by 46.5 million metric tons.

The Pan-Canadian analysis is timely, coming just weeks after leaders of Canada, Mexico, and the U.S. agreed to collectively source 50 percent of North American electricity from clean sources by 2025. Given the U.S. generates 33 percent of its electricity from non-emitting sources of generation and Mexico gets only 18 percent, the target is yet another clear incentive to leverage Canada's tremendous renewable energy capabilities.

And like the PCWIS, the Three Amigos agreement recognizes the importance of inter-jurisdictional cooperation. The pact includes supporting the development of cross-border transmission projects, and conducting a joint study to better understand the planning and operational impacts of integrating ever-increasing penetrations of variable energy sources.

FOUR PROJECTS IN WORKS

Working with the U.S. to build new transmission infrastructure is key.

There are already at least four major projects on the drawing board, including two planned links between Québec and New England, one transmission line increasing transfer capacity between Manitoba and Minnesota, and an underwater cable between Ontario and Pennsylvania.

Removing market barriers with coordinated grid planning and operations is also key.

There is an even more fundamental step required, however, if we are going to close the gap between the potential for Canadian wind-energy exports and getting new wind-energy projects in the ground. We need to get the customer on board.

There are some early-mover states, but for many U.S. decision makers, looking outside their home turf for solutions to their challenges is not always a natural step. Educating American legislators and consumers about what Canada has to offer, and how it benefits the U.S., is essential.

TECHNICAL GUIDE

That is one of the reasons CanWEA teamed with a consortium of industry and government partners to produce a technical guide showing U.S. state-level policymakers how to use clean-energy resources from Canada to comply with the CPP targets, as well as other U.S. environmental policy goals. The report, written by the global economic consulting firm The Brattle Group, helps state policymakers and environmental regulators, public utility commissions, and elected state officials understand their options, but it also provides recommendations for ensuring they meet their objectives in the most cost-effective way.

A policy discussion also needs to take place north of the 49th parallel. Shifting the conversation from pipelines to power lines is a good start, but Canada still has work to do to really seize the clean-energy opportunity.

The Brattle Report shows what U.S. states can do to access carbon-free electricity from Canada, but we need to develop and implement a renewable-energy export strategy to make sure we have the products they want and the ability to deliver them.

Canada may have the cleanest power system in the G7, but the PCWIS demonstrates that it is possible to go much further. That is important because the only way to get the large-scale emissions reductions required to address climate change is to aim for a 100 percent zero-emissions grid and to use that clean electricity to power Canada's vehicles, buildings, and industry, and help our U.S. neighbors do the same.

Syncing Up the Data

Project aims to standardize wind-turbine information in Canada.

By Marianne Rodgers, Alexander Medd, and Tom Levy

At the end of 2015, Canada had commissioned more than 11,000 MW of wind-power capacity, and even more wind farms will be coming online in the coming years. Although the wind industry supplies approximately 5 percent of Canada's electricity needs, to date it has not benefited from a broad and consistent understanding with respect to its performance, especially when compared to data that is available for traditional forms of energy.

While some sources of information do exist with regards to wind-energy data, these tend to conflict with each other and typically underestimate basic details such as tracking current installed wind-energy capacity. With the current federal and provincial focus on climate change, it is increasingly important to have access to reliable and consistently produced baseline data for renewable energy — in particular wind energy — which is one of the fastest growing sources of new electricity in Canada. Moreover, as wind parks transition from construction to operation and maintenance, the need for comparative statistics also increases. Power generation is a competitive business, and when electricity prices are low, wind energy has extremely low margins due to lack of fuel costs. So it is critical to track all causes and occurrences of downtime to direct process improvements and forecast future expenditures.

Wind turbines at North Cape, PEI.

RECOGNIZING A NEED

The Canadian Wind Energy Association (CanWEA), along with CanWEA members who are wind-farm owners and operators throughout Canada, have recognized the need for standardized reporting to support wind-industry internal benchmarking, preventative maintenance, and research.

In 2014, CanWEA initiated a pilot project to collect key performance indicators from wind-turbine owners within the CanWEA membership. There is a precedent for this type of wind-energy data collection in other countries — for example, SPARTA, which is run by private companies in the UK, and CREW, which is run by Sandia National Laboratories in the U.S.

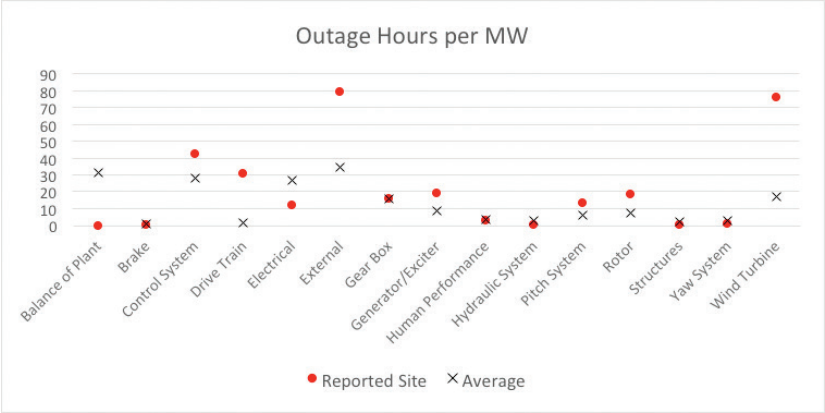

Figure 1. Representative plot depicting typical data of outage hours per megawatt that could be shown as part of a report to the owners/operators, with the values for each wind farm for each of the 15 categories in gray and the average value and reported site values highlighted.

CanWEA has non-disclosure agreements for data collection with CanWEA member wind-turbine owners and operators who comprise 30 percent of the installed wind-energy capacity in Canada.

Canadian wind-turbine owners and operators who took part in this pilot study agreed to adopt the existing Generating Availability Data System (GADS) format, which is a program developed by the North American Electric Reliability Corporation (NERC) that acts as a database where all conventional electricity generators with plants of greater than 20 MW capacity contribute.

This format was selected not only because the document is well-prepared, but because NERC soon will require wind plants 75 MW and larger with a commissioning date of January 1, 2005, or later to report their performance and availability metrics. GADS data has been used for other types of generation for reports that provide industry and policy makers with a quantitative baseline of the distribution, capabilities, and status of that generator type. While GADS data for wind farms will be collected by NERC, it is unclear what information will be available for research.

For example, with regards to the Electricity Supply and Demand (ES&D) database, NERC collects, maintains, and annually publishes its data, including 10-year projections. However, there is little interpretation or analysis. Rather, the data is presented "as is." While these data are useful, their utility is limited to system planners and a select few researchers. Therefore, policy makers and individual owners are expected to have a more challenging time with regards to unlocking the full value of NERC-published data for their own purposes.

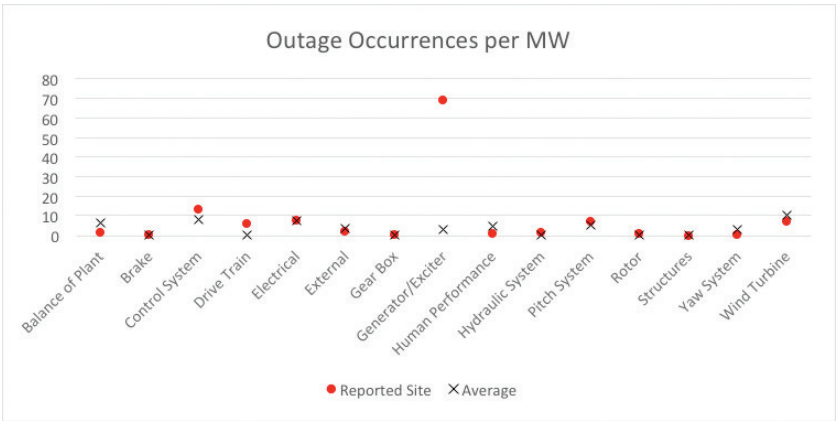

Figure 2. Representative plot depicting typical data of outage occurrences per megawatt that could be shown as part of a report to the owners/operators, with the values for each wind farm for each of the 15 categories in gray and the average value and reported site values highlighted.

The Wind Energy Institute of Canada (WEICan) has recently taken a leadership role in the pilot phase of this project, working with CanWEA in collecting, integrating, aggregating, and analyzing data from 28 wind farms across Canada from 2014 and 2015, which comprised approximately 13 percent of the installed wind capacity in Canada. Participants receive a yearly report showing how their wind farms' performances compare to the Canadian average. All data is confidential, and representative data is used for public reports. This project is helping to establish a standard for wind-energy data collection and analysis in Canada.

OBJECTIVES

The data collected as part of this project has the potential to provide insight into wind-farm performance and availability to CanWEA, wind-turbine owners and operators, government officials, and research laboratories. There are many possible benefits from the consistent, reliable and aggregation of wind production and availability data in Canada.

From an owner's perspective, these data will allow individual companies/owners to benchmark their performance and direct preventative maintenance. These data can also aid CanWEA and the broader wind industry with respect to external communica-

tions with various stakeholders (for example: public, government, and utilities).

While policy makers do not have access to this data currently, it is clear that access to aggregated baseline wind-energy data could help inform climate-change discussions and could be used to support future energy research related to the wind-energy industry within Canada.

It is hoped that as the dataset grows and its value is demonstrated, more CanWEA members who are turbine owners and operators in Canada will elect to be part of this program.

GADS FOR BENCHMARKING

One of the main functions of the program is to help wind-farm owners benchmark their performance. The ability to benchmark performance and direct maintenance efforts using GADS is heavily reliant on the data structure. In this project, operators submit data to WEICan, and outages are sorted into 132 codes, ranging from catastrophic gearbox failures to burnt-out tower navigation lights.

The 132 codes are then distilled into 15 categories with broad classifications such as electrical and gearbox. Downtime and occurrences also are split into three categories: planned, forced, and maintenance to provide a refined look at outage types. Participants in the program are provided reports based on the 15 categories, which compares their individual outage occurrences and downtime per category with the average of all data submitted. Comparisons are made on a per-megawatt basis and on a per-turbine basis to make accurate and useful comparisons between turbines of different sizes.

Other indicators such as capacity factor, availability, and site conditions also are compared. Examples of plots that are part of these reports are shown in Figure 1 and Figure 2, where representative plots showing outage hours per megawatt and outage occurrences per megawatt are shown, respectively. In these plots, the relevant values are shown for each of the 15 categories for each wind farm, with the average value and the site being reported individually highlighted.

Based on the reports, wind-turbine operators will be able to see where their turbine fleet is excelling or falling short in terms of maintenance requirements and outages compared to other wind farms taking part in the project. As the number of participating parties increases and multiple years of data are accumulated, the value of trends, performance benchmarking, and overall accuracy of the dataset will improve.

EMERGING TRENDS

While much of the wind-energy capacity in Canada has been commissioned in 2009 or later, a significant number of wind turbines across Canada are either off warranty or will be coming off warranty over the next number of years. In addition to the growing fleet of operating wind turbines in Canada (6,000 and counting), provinces are expected to slow down procurement of more wind projects for at least a few years. During these times, the GADS data collection program will be important as it is prudent for the wind industry to make rational and timely investments in operations and maintenance activities, which includes, among other things, collecting performance metrics (for example: production, availability, and outage data). It is expected these data can be used to support internal benchmarking and decision making, and they can help ensure investments are made appropriately in long-term operations and maintenance activities.

As the database for GADS expands year-after-year, trends will begin to emerge for downtime and occurrences for wind farms. Along with the data collected from owners and operators' internal programs, correlating the outage trends found in GADS to maintenance expenditures will help wind-farm operators forecast their maintenance costs for their fleet. Having this knowledge will then aid operators in estimating the actual economic service life of their fleet rather than relying on the approximately 20-year life typically quoted by manufacturers, but that has yet to be broadly tested in Canada.

Economic service life differs from mechanical life in that it takes into account the running costs of the plant and allows the operator to determine when it is most cost effective to decommission the existing fleet and take on the capital cost of new turbines to replace the existing turbines, as opposed to continuing to maintain an aging fleet with presumably out-dated technology, whose O&M costs will only continue to grow. The operators should then be able to direct their efforts at a specific group of turbines that seem to be problematic or direct their efforts toward improving, for example, the reliability of the pitch system on their entire fleet of turbines.

GADS FOR POLICY DEVELOPMENT

Given the Canadian government's renewed emphasis on data-based decision-making, the Canadian implementation of GADS could become an extremely important tool for energy and environmental policy. As the number of wind farms participating in the Canadian performance and availability benchmarking data pilot increases, a clear, data-based picture of the Canadian wind industry as a whole will begin to form.

CanWEA is considering making project data available to policy makers as part of an expanded program

Wind turbines at North Cape, PEI.

going forward. With the current focus on climate change, the aggregated project data would provide policymakers with an accurate baseline of renewable energy in Canada. Additionally, when the aggregated data from this work is compared to GADS results from traditional generation methods such as natural-gas turbines, it would allow policy makers to make direct comparisons of generation methods and base their policy on an impartial and standardized data source.

GADS FOR RESEARCH

Although each wind farm results in less than 20 data points in this work, the data arising from multiple wind farms across Canada over several years provides many rich research opportunities.

CanWEA also is considering making project data available to research organizations other than WEICan as part of an expanded program going forward. Access to such aggregated data would allow researchers to take a deeper look into trends, beyond the aforementioned reports. Factors such as seasonal effects, turbine size, turbine age, and provincial differences could be examined. When these data are correlated to other data sources, such as condition monitoring tools and weather/climate characteristics, it could be used to develop tools to help determine the service life of the turbines.

THE FUTURE OF GADS IN CANADA

Owners, operators, and the Canadian wind industry can benefit from compiling detailed baseline availability data through an established format, such as GADS. These data will continue to be collected and analyzed for wind farms in Canada with aspirations to have all wind farms report. The wealth of data obtained will be critical to ensuring an informed view of wind energy, helping demonstrate the economic viability of wind power in Canada, and help continue to increase the market penetration of this renewable resource.

WEICAN: CANADA'S STRONG WIND RESOURCE

WEICan is a not-for-profit, independent research institute whose mission is to advance the development of wind energy across Canada through research, testing, training, and collaboration. With federal funding from the Department of Natural Resources' Clean Energy Fund, the Institute has built a state-of-the-art $25 million, 10 MW wind park with a 1 MW/2 MWh battery energy storage system. The Institute's site has a strong wind resource and a 300-degree exposure to the Gulf of St. Lawrence, which allows for relatively low turbulent winds.