

# **Review of Wind Power Results in Ontario: May to October 2006**

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## **Summary**

Wind power is a major new and rapidly expanding technology for supplying electricity in Ontario. This study reviews and analyzes the actual performance of wind power in Ontario with a view to accommodating as much wind generation as practical while protecting the consumer interests of affordability and reliability. The study presents results from a synchronized database of actual wind production and consumer demand. Recognizing that the production experience to date covers a relatively short period of seven months, this study makes the following observations:

- Capacity factor so far is 22.3% (not including results from a wind farm apparently experiencing start-up problems);
- Periods of very low or no production were particularly common during high-demand periods;
- High but highly variable wind production during low demand periods was common; and
- The hourly production pattern in most months demonstrated a declining average output during the 4 a.m. to 8 a.m. period – a period when consumer power usage consistently increases.

The study finds that two previous forecasts of wind power's contribution to reliable Ontario generation capacity during the summer<sup>1</sup> significantly over-estimated the value of wind power relative to the experience during 2006. Energy Probe is concerned that a clean and promising generating technology is being burdened with unrealistic forecasts of reliable production at times of high electricity demand that are not consistent with the actual production experience. In aid of understanding the overall value of electricity with wind power's characteristics, Energy Probe's study recommends a location-specific consideration of wind power's productivity integrated with an analysis of the associated transmission and backup power implications of wind power development. Such analysis

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<sup>1</sup> The IESO has been applying a forecast of 10% of wind power's name plate capacity as firm supply for the purposes of planning summer peak electricity production requirements. More recently, GE Energy issued the GE Wind Power Integration Study released on October 24, 2006, discussed on the following pages.

is necessary to estimate the overall future consumer and environmental implications of expanding reliance on wind generation.

Energy Probe's study concludes that developing solutions for wind power's variability should include:

- Analysis of impacts on non-wind generation requirements during high and low wind production events;
- Consideration of electricity storage options;
- Consideration of load management options to increase and decrease power usage on short notice;
- Research on wind output forecasting;
- Local and inter-regional transmission impact assessment;
- Monitoring of ancillary service cost impacts; and
- Locational targeting of wind development.

## Introduction

Wind power is an environmentally attractive form of renewable energy from an overall toxicity and fuel use perspective. If wind power can be supplied to consumers at reasonable prices, it is a technology with vast potential. Ontario should seek to connect as much wind generation as practical while protecting the consumer interests of affordability and reliability. In achieving this, it must be recognized that the intermittent nature of wind power presents special technical and economic challenges that must be overcome if wind power is to be effectively incorporated into our electricity supply. In addition, connecting wind power to the grid may require transmission upgrades that must also be included in evaluating cost-effectiveness and reliability.

European grid operations officials are currently investigating what role, if any, wind power may have played in contributing to the massive blackout that struck approximately 10 million customers on Sunday, November 5, 2006 across a wide area of Europe.<sup>2</sup>

Wind generated electricity is characterized by short-term output unpredictability and variability to a much greater extent than any other major power generation technology. Integrating any power source onto power grids serving customers demanding high standards of reliability presents technical and economic challenges, but in the case of wind power these challenges are particularly difficult and warrant special consideration.

The purpose of this study is to review the performance of wind power in Ontario, with particular attention to the period since the beginning of wind farm operations greater than 20 MW in the spring of 2006. This study comments on the GE Wind Power Integration Study released October 24, 2006 and hereafter referred to as the GE Study.<sup>3</sup> Energy Probe's study also provides recommendations arising from the observations of the performance results.

According to the Ontario Power Authority's (OPA) Supply Mix Advice and Recommendations, currently let or planned contracts will create 1,390 MW of on-line wind capacity by 2010. Of this, 1,261 MW was contracted under the Ontario government's power contracting requests for proposals (RFPs). One such RFP concluded in 2004 and another in 2005.

Major wind power developments beyond those currently contracted are anticipated. At the direction of the Ontario government, the OPA is planning to have a total of 5,000 MW of wind power in service by 2020. The David Suzuki Foundation has recommended 8,000 MW by 2012. A study prepared by Helimax, a wind industry consulting firm, for the OPA identified 13,431 MW of wind-generation potential within 20 kilometres of the existing electricity grid in Ontario south of the 50th parallel.

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<sup>2</sup> <http://www.euractiv.com/en/energy/blackout-puts-outdated-power-grid-spotlight/article-159530>

<sup>3</sup> <http://www.ieso.ca/imoweb/pubs/marketreports/OPA-Report-200610-1.pdf>.

## Production Results

This study focuses on the following wind farms:

- Melancthon/Amaranth (67.5 MW), which began commercial operation on March 4 near Shelbourne;
- Erie Shores/Port Burwell (99 MW) which began commercial operation on May 24 south of Tilsonberg;
- Kingsbridge (39.6 MW) which began commercial operation on March 16 near Goderich.

The production results from these three farms are grouped by month. Only farms in service for the full month are included. The 189 MW Prince wind farm located near Sault St. Marie went into service in September and would normally have been included in the October results. However, there appears to have been production problems during October and therefore results from Prince are excluded from the results shown.

This study relies on synchronized wind-production and load data assembled from raw data produced by the Ontario Independent Electricity System Operator (IESO). The IESO's production data is not billing-quality data, but a less accurate measurement used for purposes of monitoring the power system. The individual unit of wind data used is hourly average production for each farm.

One of the performance measures used in this study is capacity factor (CF), the ratio of actual production for a period to theoretically perfect production for that period. Hourly average, monthly average, and lifetime average capacity factors are reported.

The average lifetime capacity factor achieved by the three commercial wind farms in this study is 22.3%. This production result reflects only a relatively brief period of production – seven months – and is concentrated in the summer, when production is expected to be lower than the annual average. The outlook for annual average capacity factor for the entire Ontario wind fleet of large wind farms for the year April 2006 through March 2007 is likely to fall in the range of 24% to 27%.

Table #1

April-October 2006 Ontario Wind Production Results: Summary									
Month	Average Capacity Factor	Frequency of hours less than 2% CF	Most productive average hour	Least productive average hour	Capacity factor when load is below 13000 MW	Max one-hour absolute delta wind output (CF)	Correlation: load and wind output	4 to 5 "Rush Hour" Capacity Factor	Frequency of 4-5 "Rush Hour" Capacity Factor below 2%
April	26.6%	9.3%	2:00 AM	7:00 PM	31.8%	69.10%	4.80%		
May	22.1%	12.2%	1:00 AM	8:00 AM	27.6	28.70%	-34%		
June	15.3%	10.8%	12:00 PM	8:00 AM	13.6%	24.20%	-1.3%		
July	17.8%	13.6%	8:00 AM	3:00 PM	14.20%	24.60%	9.2%	21.9%	14.5%
August	13.5%	21.4%	1:00 AM	10:00 AM	5.6%	29.60%	9.8%	15.2%	25.8%
September	24.3%	10.1%	2:00 PM	10:00 PM	26.6%	36.7%	0.9%		
October	36.7%	3.8%	11:00 PM	9:00 AM	18.9%	34.0%	10.1%		

The column labelled “Max one-hour absolute delta wind output (CF)” shows the maximum change in hour-to-hour wind output, either up or down. This is one measure of wind power output variability.

A variable source of electricity whose variability correlates well with the variability of electrical demand would contribute disproportionately to reliability, and could displace more than its share of alternative generation capacity. Conversely, a variable source of electricity whose variability correlates poorly with the variability of electrical demand would not contribute significantly to reliability, or displace much alternative generation capacity. The correlation results presented for load and wind analyze the relationship between:

- The ratio of actual hourly wind output to average monthly wind output and
- The ratio of actual hourly load to average monthly load.

- The 4 to 5 “Rush Hour” capacity factor shows the actual average monthly performance for the period from 4 p.m. until 6 p.m., which is typically when summer peak demands occur.

Another Ontario-based wind production facility for which production information is publicly available is the single Windshare turbine located at the CNE in Toronto. In the first 42 months of operation, the average capacity factor of that turbine was 14.7%. Windshare refused a request to provide complete monthly production data and removed incomplete monthly production data from its website soon after this author requested the missing data. We have therefore not included this turbine’s data in our analysis, although its inclusion would generally strengthen our directional conclusions and recommendations.

The first industrial-scale wind farm in Quebec, called Le Nordais, demonstrated a lifetime capacity factor of 18% during its first five years of operation.<sup>4</sup> The company that developed the wind farm collapsed financially after less than three years of operation. Preliminary results from the Gaspé facility Cartier Wind indicate production results close to 40%. Because Quebec’s electricity demand is strongly winter peaking due to the prevalence of electric space heating, it is possible that the annual correlation between demand and wind output may be favourable.

Alberta’s wind industry has a substantial operational history and has demonstrated relatively high production results. However, the output of all of the major wind farms is highly correlated and demonstrates poor short-term correlation with winter loads, when Alberta demand peaks. Powerful episodic warm winter “Chinook” winds generate electricity during times when electricity usage is typically low, whereas during cold snaps when usage is high, wind output is sometimes minimal. These factors, combined with transmission constraints and the low market share of flexible hydroelectric capacity in Alberta have caused the Alberta Electricity System Operator to limit wind power development to 900 MW<sup>5</sup> – 500 MW more than the currently installed capacity but approximately half the capacity currently being actively considered for development.

In Germany in 2004, the annual capacity factor was 19.1%. In 2003-2005, the average annual capacity factors of the wind generators served by E.On Netz – the grid operator hosting the largest amount of Germany’s wind capacity of any grid operator – were 15.5%, 18.3% and 18% respectively.<sup>6</sup>

As a crude rule, 30% capacity factor is often considered the minimum needed for economic production.

The average monthly production record to date for each of the three Ontario wind farms is as follows:

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<sup>4</sup> <http://www.regie-energie.qc.ca/audiences/3526-04/mainMemoiresParticip3526.htm>, Mémoire Groupe Axor (23 avril 2004)

<sup>5</sup> [http://www.aeso.ca/files/July\\_19\\_Stakeholder\\_Session\\_Pres\\_v8.pdf](http://www.aeso.ca/files/July_19_Stakeholder_Session_Pres_v8.pdf)

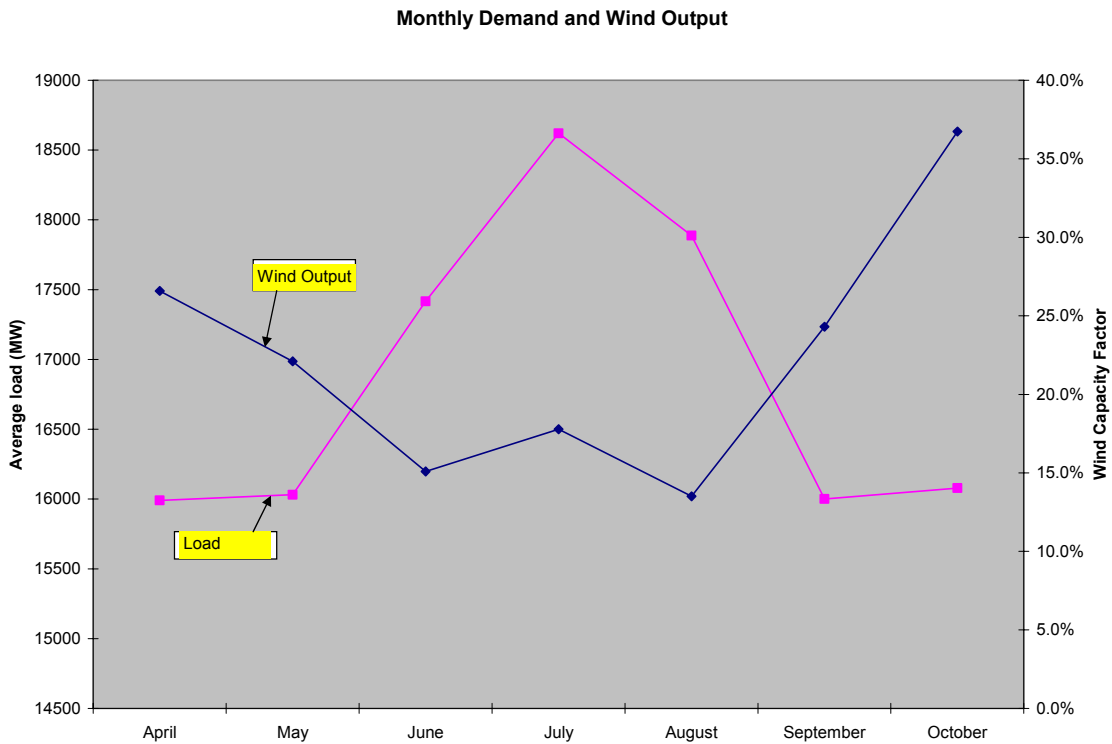
<sup>6</sup> <http://www.aweo.org/windEon2004.html> and E.On Netz, 2005 Wind Update Factsheet\*.

Table #2

	Amaranth CF	Kingsbridge CF	Port Burwell CF
April	27.8%	24.6%	
May	22.9%	20.6%	
June	17.2%	16.5%	12.4%
July	21.9%	14.5%	21.0%
August	15.6%	15.0%	11.4%
September	22.4%	25.1%	25.3%
October	35.9%	38.9%	36.5%
Average	23.4%	22.2%	21.3%

Once an annual period of production has been completed, it will be useful to calculate the annual correlation between wind production and load. Graph #1 shows the relationship between load and wind output so far:

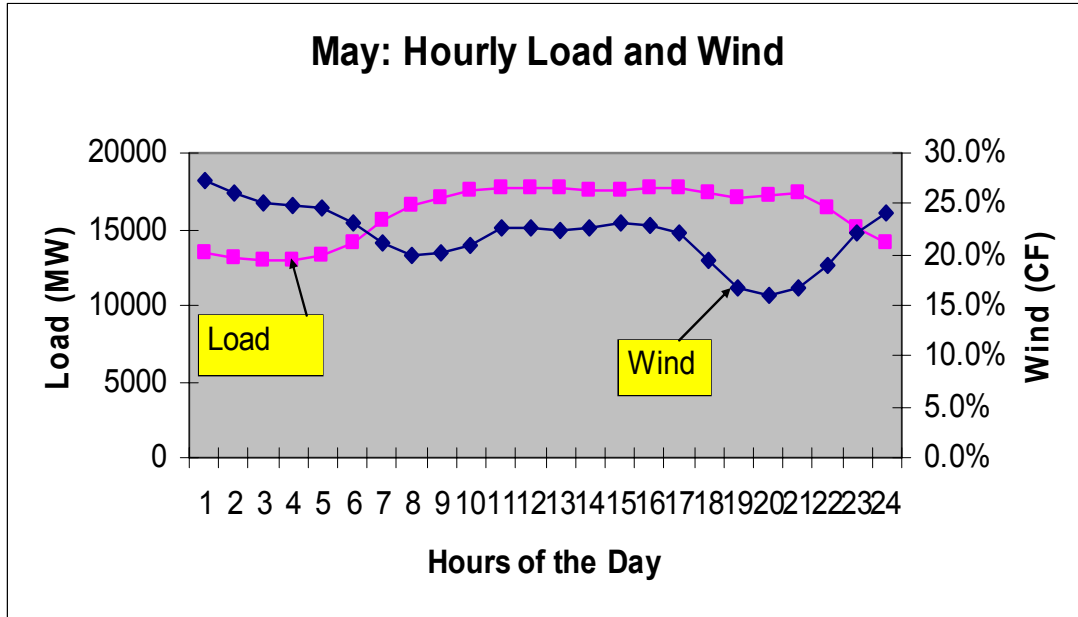
Graph#1



So far, wind output is highest in low demand months.

Graph #2 provides an example of hourly average production for May – the month showing the lowest correlation between load and wind production of all of the months of production to date.

Graph #2

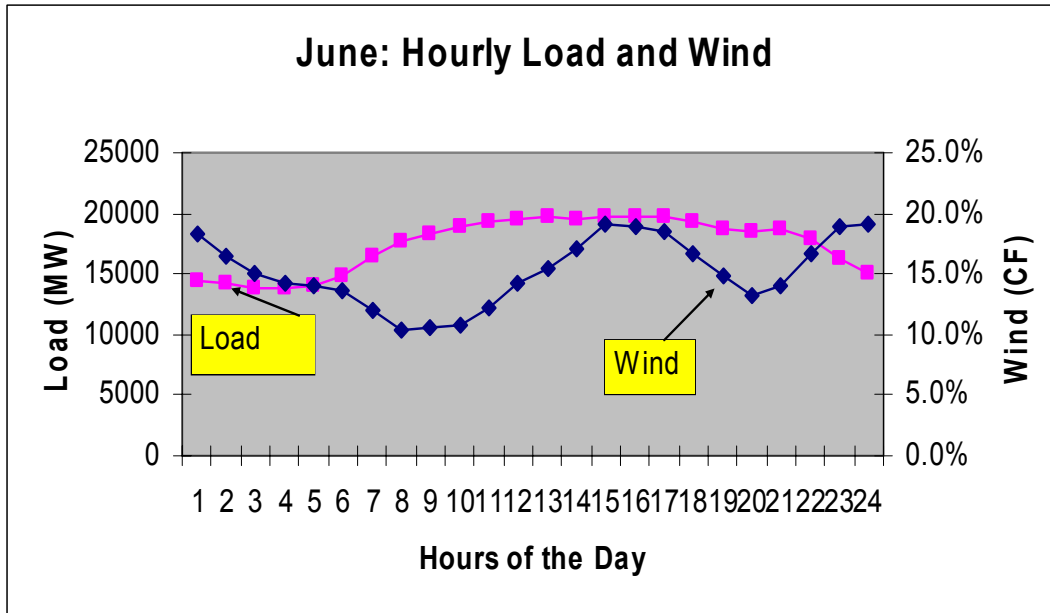


In Graph #2, notice the declining production during the early morning. This is a period when load is increasing most rapidly. The tendency toward declining wind output during the early morning places extra load on the limited capacity of other generators capable of quickly increasing output – so-called “fast ramping” units.

This pattern of declining early morning production has occurred in every month so far except September, with June demonstrating the steepest rate of average wind production decline during the early morning.



Graph #3

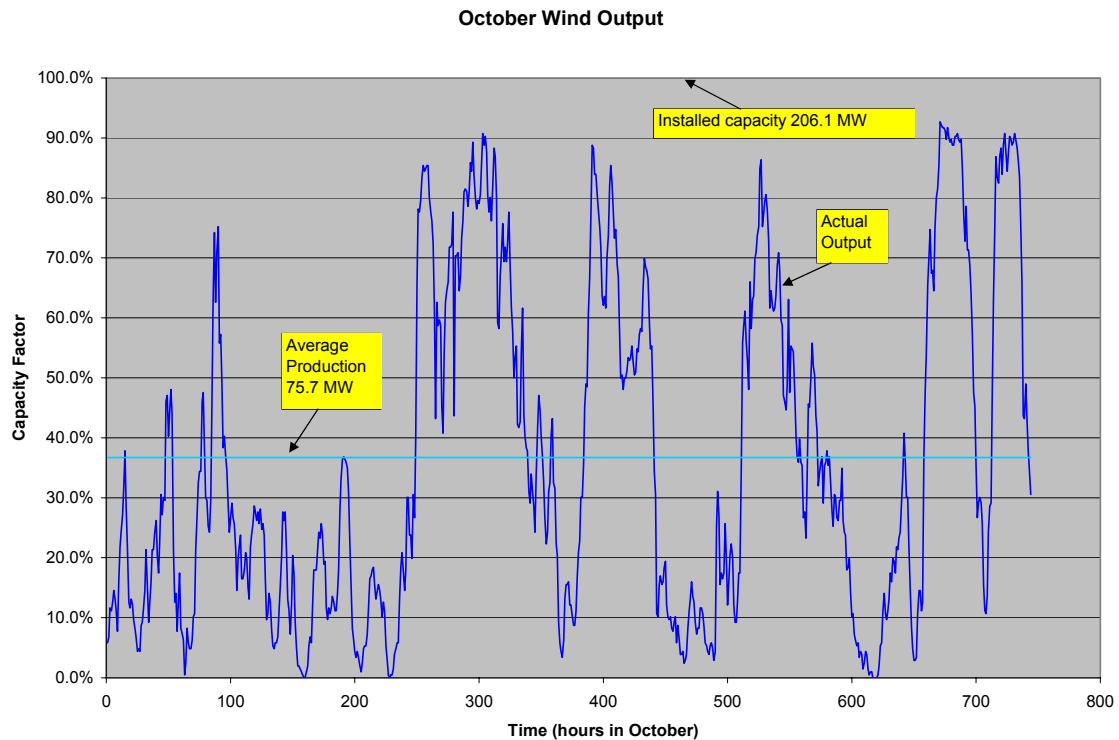


Better afternoon production in June, shown in Graph #3, improved the correlation between load and output during that month relative to May's results.

Prior to the development of wind power in Ontario, coal generation and to a much lesser extent oil and gas generation has been used extensively to meet ramping requirements. Other available methods, such as hydroelectric operational flexibility, have been fully deployed. The tendency of wind generators to decline in the morning while load is rising has increased ramping requirements on fossil generation. While Ontario's new wind generation has reduced fossil fuel generation when wind output is available, the wind production pattern whereby output falls during the early morning has offset this benefit somewhat by lowering the fuel efficiency of the flexible fossil generators used for ramping, increasing air emissions per unit of production, and perhaps increasing maintenance costs.

Graph #4 shows the production pattern during a month with the highest production achieved so far. (Note that the time axis shows the consecutive hours of the month.)

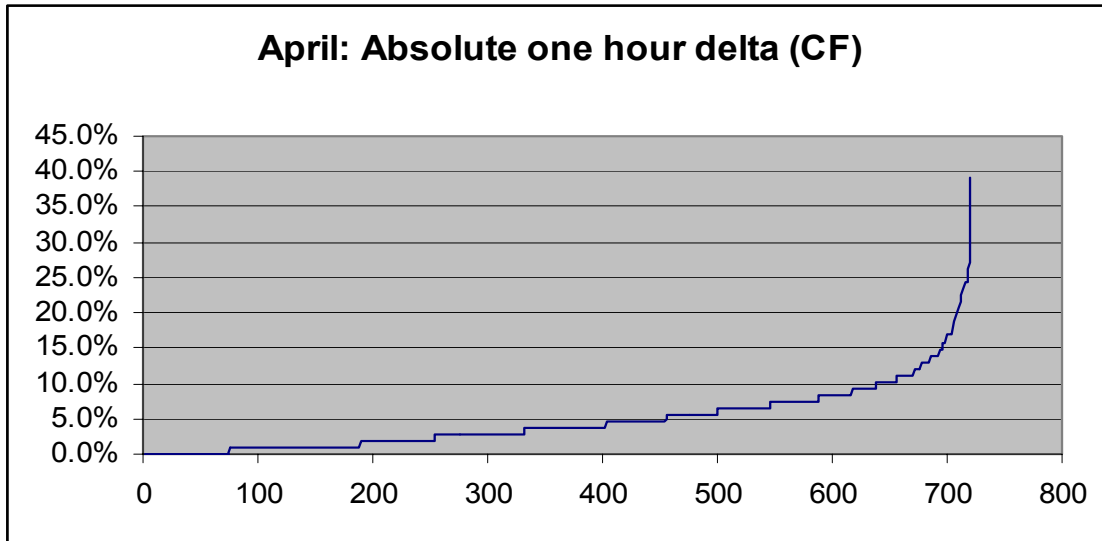
Graph #4



As Graph #4 shows, the maximum period when production continuously exceeded average production for October was only 91 hours (hours 249 through 349 inclusive). This period is by far the longest period of output above 35% capacity factor achieved so far in Ontario. During October, periods of low or no output were less frequent than in other months but still common and approximately randomly distributed.

The months with relatively high output also demonstrate greater production variability than the months with low average output. April has demonstrated the greatest production variability.

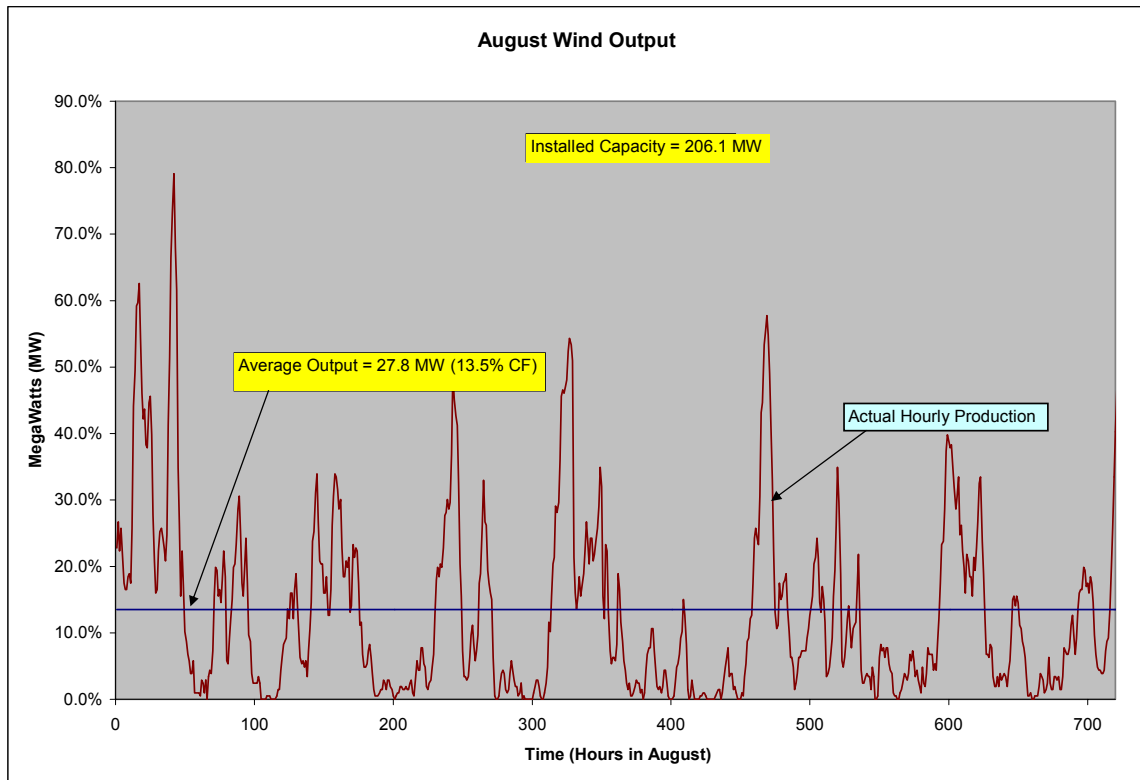
Graph #5



Graph #5 shows the experience with production variability during April. The graph shows the difference in hour-over-hour output ranked so that the hours with steady output are towards the left and the hours with variable output are towards the right. For example, during 455 hours the hour-over-hour change in output was less than 5%. In the most variable 20 hours of production, hour-over-hour changes ranged from 16.8% to 39.2% CF. In all the months examined, large swings in output appear to be randomly distributed, although statistical testing for randomness was not done.

Graph #6 shows the production pattern during August when production fell below 2% during 21% of the hours during the month. August was the month with the largest number of hours of minimal output for all months studied:

Graph #6



Although periods of low or no output were of long duration and frequent, as shown in Graph #6 relatively high wind production occurred during early August. This wind output corresponded to a period when Ontario experienced all-time record electrical demand of 27,005 MW, which was 3.3% above the previous all-time peak set in 2005.

## Comments on the GE Wind Integration Study

The GE Study was sponsored by the IESO, the OPA, and the Canadian Wind Energy Association and is being used as input for the development of the OPA's Integrated Power System Plan for Ontario.

GE Energy is the fourth largest supplier of wind generation equipment in the world.

The GE Study used no actual production results but is based on forecasted output although several months of actual results were available when the GE study was released.

The average annual production anticipated in the GE Study is 27.9%, above the top of the range Energy Probe anticipates for the year April 2006 through March 2007. The earlier Helimax study for the OPA forecast higher annual production of 29.3%.

Among its findings, the GE Study claims that with a high penetration of 10,000 MW of wind power, wind can be reliably counted on in summer for a firm supply of 1700 MW during summer peak hours.<sup>7</sup>

The Ontario Clean Air Alliance has relied upon the GE Study forecast for summer reliability in its study "Phasing out coal: 2006 progress report" issued November 9, 2006.

The GE Study is inconsistent with the results of similar studies from other electricity systems .

A 2004 study was conducted to examine the grid and reliability impacts of wind power in Germany.<sup>8</sup> Germany's overall power demand was 3.4 times that of Ontario's in 2003. Germany is also much better interconnected with neighbouring markets, with 23 major interconnections as compared with 24 major and minor interconnections between Ontario and its five interconnected neighbours. Germany's larger size and stronger interconnections are both factors that would tend to mitigate wind power impacts. The 2004 German study was able to utilize extensive actual production data. When adding a small amount of wind power to the grid, the study found that 1000 MW of wind power capacity added to the grid increased peak power firm generation capacity by only 80 MW (8% of the wind capacity). Adding 48,000 MW of wind power, forecast for 2020, the requirement for backup power is only reduced by 2000 MW (4% of the wind capacity). The German study found that the proposed tripling of wind capacity in Germany by 2020 is, in and of itself, driving a need for quintupling generation reserve requirements.

In Ontario, the IESO assumes that 10% of the installed capacity should be considered as firm capacity for meeting peak demands. A Pembina Institute study has commented on this assumption, "Given that the capacity factor for modern land-based wind turbines

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<sup>7</sup> GE Study p. 4.7

<sup>8</sup> "Planning of the Grid Integration of Wind Energy in Germany Onshore and Offshore up to the Year 2020" also known as the DENA 2004 Wind Report, issued in English, February 2005.

is accepted to range from 25%–40%, and that wind generating capacity in Ontario will be relatively geographically distributed, this may be an excessively conservative assumption.”<sup>9</sup>

Both the GE Study conclusion and the IESO’s forecast about firm summer peak reliability are inconsistent with Ontario’s actual experience.

During July and August 2006, the actual average frequency of hours when there was little or no wind output in Ontario – output less than 2% – was 18.6%. These very low production hours were about as likely to occur during the daily peak period as any other time during the day. Ontario’s experience in 2006 shows that the conclusion of the GE Study that wind can reliably supply power in summer equal to 17% of its rated capacity significantly over-estimated the actual results. The actual results for the summer of 2006 also suggest that the IESO should review its forecast that even 10% of the installed wind capacity should be considered as firm capacity for meeting peak demands. During the summer of 2006, wind power provided no firm generation capacity during the peak months.

It is likely that diversifying the geographic distribution of wind production sites, as assumed in the GE Study, will lessen somewhat the problem of unreliable production during peak times and also the problem of average production variability, but only if transmission constraints can be alleviated. Transmission constraints were not considered in the GE Study. In making its assessment, the GE Study examined wind production prospects for many regions, including regions of the province around the western end of Lake Superior, an area likely to have different wind patterns than in eastern Ontario. This diversity would normally be beneficial. However, Ontario west of Marathon on the northern shore of Lake Superior has a congested interconnection with regions east of the nearby town of Wawa – the region of the province where by far the largest fraction of load exists. Even when possible, moving power from north western Ontario to southern Ontario increases line losses relative to the average line loss fraction.

The Ontario three wind farms in service since the spring of 2006 are all located in the southwestern region of the province. The experience so far shows a high correlation in output between the three wind farms studied.

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<sup>9</sup> Pembina Institute, “The Ontario Power Authority Supply Mix Report: A Review and Response” by Winfield, Peters, and Horne, February 2006, p. 7.

Table #3

Output Correlations			
	Amaranth and Kingsbridge	Amaranth and Pt. Burwell	Port Burwell and Kingsbridge
April	86.5%		
May	66.0%		
June	65.4%	57.5%	37.1%
July	61.0%	59.7%	53.0%
August	55.8%	58.0%	58.1%
September	75.4%	63.1%	57.0%
October	73.2%	69.9%	66.9%
All average	62.6%		

Amaranth, the wind farm with the highest production, also has the highest output correlation with the other farms, a factor that reduces the overall value of Amaranth’s output.

The actual results from the summer of 2006 raise significant concerns about the assertions of the GE Study regarding dependable capacity during the peak of consumer demand.

The GE Study forecasts that with 10,000 MW of capacity installed, the variability of wind output in total MW will be less than the variability of load and that therefore wind variability can be fairly readily accommodated on the grid.<sup>10</sup> This conclusion ignores the fact that near term load variability is usually predictable within a range of plus or minus less than 1%, whereas, as demonstrated from the German experience, wind power is highly unpredictable.

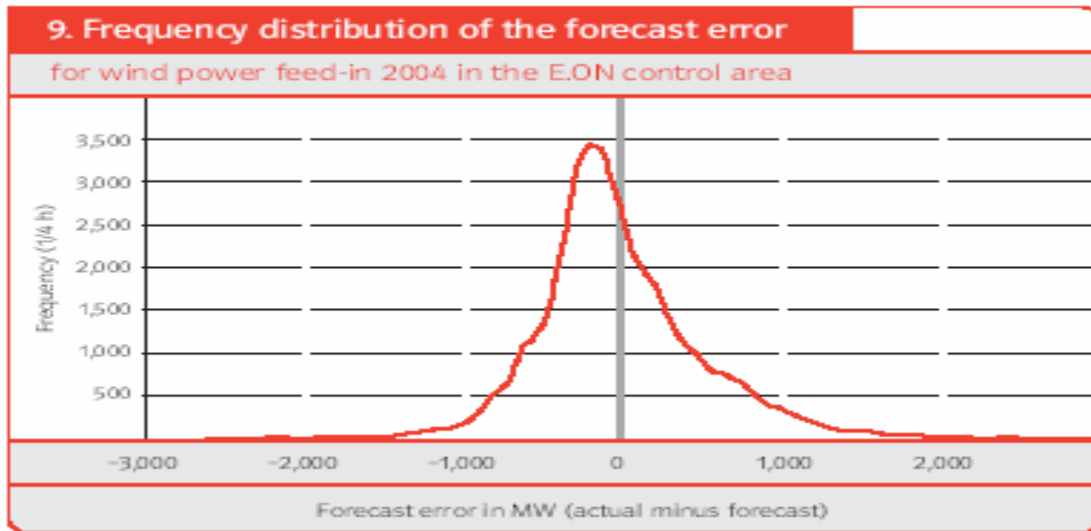
E.On Netz has made major efforts to forecast wind power production in cooperation with the Institut fur Solare Energietechnik (ISET). ISET itself reports that its forecasting system has “set standards that are exemplary in global terms.” The system is being studied by many countries.

In 2004, when E.On Netz hosted on average 6,650 MW of wind capacity, the resulting 8 hours ahead wind production forecasts were found to be inaccurate as follows<sup>11</sup>:

<sup>10</sup> GE Study, p. 5.12

<sup>11</sup> E.On Netz, 2005 Wind Report.

Graph #7



As Graph #7 shows, forecasting errors of more than 1000 MW were fairly rare however, about one third of the time forecasting errors were over 500 MW – approximately 8% of the installed wind capacity during this period.

The Alberta Electricity System Operator has recently established a wind power forecasting work group.

One issue identified in the GE Study that deserves additional study is the impact of high but highly variable wind production during periods of low demand. The concern in this case is that during low demand periods, the generators dispatched are typically those with low production flexibility – nuclear, cogeneration, and hydroelectric generators operating under maximum flow constraints. The production experience in Ontario so far is that episodes of high wind production during periods of low demand have occurred in most months. In addition, episodes of low wind production have occurred during periods of high demand every month. As the installed capacity of wind power in Ontario grows, major swings in wind power output during periods of low demand may impose additional stresses on the power system. This problem could become much more acute when all coal-fired power is removed from the Ontario grid unless the coal fleet is replaced by a sufficient fleet of generators with production flexibility and reliability characteristics comparable to the existing coal generators.



## **Recommendations for Understanding and Managing Wind Integration**

Historically, Ontario's hydroelectric generating stations were able to provide fast ramping production flexibility. This capability has been used extensively to support the production inflexibility problems presented by nuclear power stations. Two trends continue to diminish the output flexibility of Ontario's hydroelectric capacity. Hydroelectric generation has lost market share since the 1950s, thereby reducing its flexibility relative to overall swings in demand and supply. In addition, over time tighter environmental constraints have eroded the production flexibility of Ontario's hydroelectric generators. One example illustrating this trend toward new constraints on the output relates to the Madawaska River. The Madawaska River generating cascade was designed to provide extensive ramping capability. However, following serious harm to pickerel spawning in the tailrace of the Mountain Chute dam, the largest storage dam on the system, during the spring of 1995 new, much more stringent regulatory constraints on the forebay levels and flow requirements were introduced. The trend toward tougher environmental constraints on hydro-electric operations appears likely to continue. For reasons of cost control and environmental impact mitigation, any future hydroelectric development in Ontario is likely to be run-of-river generation. In-province hydroelectric production flexibility is therefore likely to provide only limited assistance for shaping the output of wind power.

Additional electricity storage capability might be justified. Compressed air and pumped storage are both technologies in widespread use around the world. The most efficient pumped storage developments use greater natural geographic height differences than can be found in Ontario. Chemical storage of electricity for grid power applications, such as using flow batteries or hydrolysis of water, has not been proven commercially viable in widespread applications yet.

Because wind power swings in output are often large and unpredictable with current technology, manual or market-based demand control measures are of limited usefulness for wind impact mitigation. Automatic load flexibility might be a future solution to wind power variability. For example, electric water heaters that had automatic thermostatic controls might be used to absorb extra power for brief periods and cut demand at other periods. However, the "smart metering" plan currently being implemented in Ontario does not anticipate this type of requirement.

Meteorological research to advance the capability to forecast wind speed accurately is underway in many jurisdictions. Notwithstanding the limited results so far, as seen from the German example, as a high priority the IESO should undertake similar forecasting research reflecting local conditions. The IESO should seek to participate wherever possible with leading forecasting efforts in other jurisdictions. Ontario-based meteorological research should be conducted independently.

While studying other wind power jurisdictions can be useful, unique local circumstances need to be considered. For example, climatic and load conditions are different in

Germany, Quebec, or Alberta than in Ontario. For example in Germany, local meteorological conditions combined with the availability of government-subsidized loan guarantees, reliance on a non-competitive standard offer payment structure, and government market share commitments for wind power appears to have created a geographically concentrated and low productivity wind fleet. Understanding and managing wind power in Ontario needs to be analyzed on a local level.

The transmission system impacts of wind development need to be examined in detail through independent studies. The GE Study did not address transmission considerations.

Expanded transmission capability within Ontario and between Ontario and interconnected regions will be required to manage wind power. However, since many of Ontario's neighbouring jurisdictions are also developing wind power, the benefits of interconnection will be less than would occur if only Ontario was developing wind power. For example, Quebec is in the process of developing 4,000 MW of wind power. New York, with whom Ontario has its strongest electrical interconnections, is also experiencing rapid wind power development. This development is concentrated in regions near the Ontario border that, even in advance of wind power development, tend to be transmission constrained in delivering power south. During high wind power output periods in low Ontario load periods, Quebec and New York may be experiencing the same phenomena. Ontario should undertake joint wind integration research with neighbouring jurisdictions. One objective should be to identify the extent of correlation of high and low wind output between regions. Another objective should be to examine regional transmission system impacts. Inter-regional wind power integration research should be conducted independently

As identified by E.On Netz in its 2005 study, if other load shaping options are not sufficiently developed, flexible output standby generation with capacity approaching the capacity of the installed wind generators will be required. Back-up power requirements and impacts should be assessed. Since low-efficiency fossil generation is usually required for performing this function, some of the environmental advantage of wind power will have to be sacrificed if grid reliability is to be maintained. If natural gas generators are going to be used to backstop wind power, natural gas supply issues related to pipeline and storage capabilities and associate rules in gas markets will have to be considered. Any impacts whereby hydroelectric generation is spilled or hydroelectric facilities are required to operate inefficiently in order to accommodate wind should be identified so they can be minimized.

Power grids require various reliability-related technical performance requirements, mostly provided by specially equipped generators or specialized transmission equipment. These include operating reserves, automatic generating control, black start, and reactive power among others. Collectively, these services are known as ancillary services. Ontario's IESO is responsible for managing ancillary services and employs market-based and non-market based process for obtaining needed services. The IESO and the Market Surveillance Panel should routinely monitor the ancillary service costs to identify and quantify any impact wind power is having on increasing consumer costs in this area. The

costs impacts of wind power should be estimated by comparing actual ancillary service costs with what those costs would have been without wind power, taking into account the offers to sell and bids to buy received by the IESO.

The Ontario government's current procurement strategies for wind power are indiscriminate with respect to location. However, the overall cost and environmental impacts of wind power development in some regions of the province will be very different depending on local conditions of load and alternative generation. For example, north western Ontario has a strongly winter peaking demand for electricity – a factor that favours wind – but low overall generation costs and negative load growth, both factors that would suggest that wind investments would be better directed toward eastern Ontario. It is also possible that Southern Manitoba or nearby states in the U.S have more favourable wind regimes relative to the needs of north western Ontario as compared with the service local wind generators can provide.

## Conclusions

Energy Probe advocates accommodating as much wind generation as practical while protecting the consumer interests of affordability and reliability.

Understanding the overall consumer and environmental implications of developing wind power in future requires understanding the patterns of wind power productivity relative to consumer needs. The benefits of wind power associated with avoiding the output from non-wind generators needs to be considered. However, a complete understanding of wind's impacts also requires taking into account the incremental consumer and environmental costs of transmission and back-up power requirements associated with wind power development.

In summary, developing solutions for wind power's variability should include:

- Analysis of impacts on non-wind generation requirements during high and low wind production events;
- Consideration of electricity storage options;
- Consideration of load management options to increase and decrease power usage on short notice;
- Research on wind output forecasting;
- Local and inter-regional transmission impact assessment;
- Monitoring of ancillary service cost impacts; and
- Locational targeting of wind development.