Canadian Electricity Association
Association canadienne de l'électricité

Canadian Electricity Association

An Assessment of the Prospects for Wind Power Development in Canada

December 2004

Introduction

Canadian Electricity Association (CEA) members are the largest owners and operators of wind-powered generation in Canada. These companies view wind generation as another alternative in the suite of technology options necessary to maintain diversity in the nation's power generation fleet. That diversity is essential, as it helps companies deliver reliable, affordable, and sustainable supplies of electricity to Canadians. It permits the industry to balance the strengths and weaknesses of various technologies in meeting power needs.

However, CEA members recognize that, although wind power is just one amongst many technologies available to meet our electricity needs in Canada, it is currently in a unique position, for two reasons. First, wind power generation is the current technology of choice amongst media, the environmental community, and many in government in Canada. Moreover, the recent federal election highlighted the wind-friendly energy positions shared by the Liberals, NDP, Bloc Quebecois and Conservative platforms. Second, the development of applications of wind technology has great momentum worldwide, as the growth rate, year over year, continues at around 25%. Although this growth is from a small base, it remains a clear indicator of interest, reflecting both increased socio-environmental concerns around other technologies and rapidly declining development costs for wind itself.

For Canadians, increasingly concerned about the reliability of their electricity supply further to the August 2003 blackout and on-going market condition changes, and about the environmental performance of electricity power generation in the context of climate change, air emissions, and land and water use concerns, it can often seem that wind is the answer to what ails us. Across the country, many Canadians are asking, why isn't there more wind power generation in Canada, and how much of our electricity needs could be met by wind?

The Canadian Wind Energy Association (CanWEA), responding to these and related questions, has committed itself to a specific target – 10,000 megawatts of installed wind power capacity by 2010. Given that current installed capacity stands at approximately 439 megawatts (MW), this target would require an annual growth rate of 60%. As high as this is, it should be noted that several European countries have seen their wind power capacity develop at very high growth rates: Germany went from 2,800 MW to 14,600 MW of installed capacity in 5 years; and Spain, with 830 MW installed in 1998, set a target of 13,000 MW by 2011 and is already at the 6,000 MW mark.[i] However, it should also be noted that rapid growth rates for wind power in Europe have been facilitated by electricity prices significantly higher than those in North America, more substantial government support programs, and more strongly interconnected transmission networks[ii].

Over and above the CanWEA target, there is a great deal of talk across Canada about how wind could meet a significant portion of our power supply needs. Given the relatively limited operating experience with wind in Canada, CEA member companies don't yet feel comfortable about speculating about how much wind power the country can accommodate in its generation portfolio. They do believe that the opportunities for development are significant, but caution that the technical challenges are sizeable – and feel strongly that both the opportunities and challenges need to be better understood to have a truly informed public policy discussion.

For these reasons, CEA has prepared the following assessment of wind technology and its potential. This is a discussion paper, not a detailed technical analysis. It is offered to government decision makers, and others interested in wind power, to deepen the understanding of how wind technology, and electricity generation technology in general, is assessed by electricity companies as part of the overall generation mix in Canada.

Wind Power Generation: The Economic Fundamentals

Since 1990, wind generating capacity world-wide has shown an average annual growth rate exceeding 30%.[iii] Canada has seen a constant increase in installed capacity, with annual growth rates averaging about 26% since 2000[iv] to approximately 439 MW now or less than 1% of Canada's gross generation capacity. The following chart provides a breakdown by province and territory of wind power production in Canada.

Canadian wind energy installed capacity and production and % share provided by CEA members (December 2004)

Province or territory	Total Installed Operating Capacity	Installed CEA Member Capacity	CEA Member Electricity Production	CEA Member Electricity Production	CEA Member Percentage of Total Provincial Installed Capacity
	(in MW)	(in MW)	(in MWh)	(in GJ)	% - Prov./Canada
Nfld. & Labrador	**0.39***	**0.39***	0	0	100.0 / 0.1
Nova Scotia	**4.86**	**1.26**	3,154	11,353	25.9 / 0.3
New Brunswick	**0.00**	**0.00**	0	0	0.0 / 0.0
P.E.I.	**13.56**	**10.56**	13,876	49,953	77.9 / 2.4
Québec	**113.25**	**113.25**	170,000	965,569	100 / 25.8
Ontario	**15.75**	**6.90**	19,000	66,000	43.8 / 1.6
Manitoba	**0.00**	**0.00**	0	0	0.0 / 0.0
Saskatchewan	**21.78**	**21.78**	72,093	259,534	100 / 5.0
Alberta	**268.67**	**190.00**	247,952	1,392,626	70.8 / 43.31
British Columbia	**0.00**	**0.00**	0	0	0.0 / 0.0
Nunavut	**0.00**	**0.00**	0	0	0.0 / 0.0
N.W.T.	**0.00**	**0.00**	0	0	0.0 / 0.0
Yukon	**0.81**	**0.81**	2,131	7,673	100 / 0.2
Total Canada	**439.07**	**324.95**	**614,560**	**2,215,823**	**74** (Canadian %)

*currently under commissioning
Sources: Canadian Wind Energy Association and the REDI file [Note: CEA has tabulated member company totals]

A host of recent initiatives across Canada will significantly augment these numbers. In June 2004, P.E.I. announced that 40 wind turbines will be added to the province's windmill farms in order to produce 15% of the Island's electricity from wind power by 2010. In October, Nova Scotia announced that it had accepted bids for 28 MW renewable power, including 25 MW generated by wind power. NB Power released an RFP for wind power in winter 2004 and this past spring awarded a contract for 20 MW of wind to be developed on Grand Manan Island. Following the government of Québec's announcement of a 1000-2000 MW wind power development target by 2012, Hydro-Québec Distribution selected Cartier Wind Energy Inc. (50% owned by TransCanada Corporation) and Northland Power Inc. to develop a total of 990 MW. Ontario is currently soliciting bids for 300 MW in renewables through an RFP and has announced a provincial RPS for 5% of electricity by 2007 and 10% by 2010 – wind power is expected to meet much of this demand. Manitoba Hydro is negotiating a power purchase agreement with a private developer for the output of a 99MW wind farm, to be in service in 2005 and has established a target of 250MW of wind generation by 2009, subject to its economic viability. In June, EPCOR Power announced an agreement with Port Albert Wind Farm Ltd on a 53.6 MW proposed wind farm on the shores of Lake Huron in Ontario. In October 2004, SaskPower announced plans to build a 150 MW Wind Farm near Swift Current Saskatchewan with an in service date of early 2006. SaskPower has signed a contract with Vestas-Canadian Wind Technologies Inc. for the supply and installation of 83 wind turbines for this project.

As support for these projects and others to come, the federal government launched a National Wind Atlas developed by Environment Canada, with co-funding from Natural Resources Canada, and the creation of a website to ensure widespread use of the instrument at CANWEA's national conference on October 18, 2004. Natural Resources Minister John Efford also announced WPPI funding of $24.7 million for the recently commissioned 68.4 MW Summerview Wind Farm near Pincher Creek, Alberta that is operated by Transalta's Vision Quest division.

A consequence (and a cause) of significant Canadian and worldwide installations is that the cost of wind energy is approaching the cost of more conventional technologies in Canada. CanWEA reports an 8 to 12 ¢/kWh cost for wind generation at recently constructed wind farms in Québec, Ontario and Alberta (all figures in CDN$).[v] Expansion of SaskPower's Cypress Wind facility will cost around 7 ¢/ kWh. Contracts awarded by Hydro-Québec Distribution in October will be paid 6.5 ¢/ kWh plus an additional 2.2 ¢/ kWh for system integration and balancing costs for total cost of 8.7 ¢/ kWh.[vi] It is expected that as a result of economies of scale, there may be additional cost reductions as larger machines are deployed in larger wind farms.

Moreover, the gap between conventional and wind generation costs in Canada is being partially offset by the Wind Power Production Incentive (WPPI), which will pay its recipients an average of about 1 ¢/kWh during the first ten years of a new wind farm's production. Similar to other incentives[vii] available today, the WPPI subsidy makes new wind developments more economically viable.[viii] As noted above, the 2004 federal election campaign elicited a number of wind-friendly proposals by all federal parties, so it is likely that there would be broad parliamentary support for a significant expansion of WPPI.

That said, even with WPPI, the price of wind remains higher than most conventional technologies. As with any technology, there are a range of issues affecting the economics of wind, including the following:

- the cost of competing energy sources
- incentives paid by Government for the technology
- installation costs of wind farms
- the costs of needed additions to the transmission lines, stations and interconnections[ix]
- the costs of integrating and of balancing the output of a fluctuating and intermittent source
- the quality of wind resources in locations easy to integrate to the existing grid and
- the lack of a domestic manufacturing base (were one in place there would be a reduction of freight and exchange rate costs, which – if production costs were comparable to those in Europe – would have a net positive cost impact on systems).

The price of any electricity is composed of, amongst other things, energy (the kWh actually produced) and power (the instantaneous MW that can reliably be produced, also known as capacity). Electricity from wind represents significant energy potential, because significant numbers of kWh can be produced. However, its ability to provide reliable power is constrained due to its intermittent nature and inability to be dispatched at will. Understanding this "technical constraint", and how it translates into market value, requires some general review of the basics of electricity generation.

The Basics of Electricity Generating Systems

Electrical systems require equilibrium between load demand and power produced. If production is bigger or smaller than load, frequency and voltage will change and this can create technical problems. Since there is currently no cost-effective large-scale method of storing electrical energy, electricity must be consumed the instant it is generated.[x] To sustain this balance, the electric system must provide power at the instant the load demands it, and at the prescribed frequency and voltage limits. Variations outside of these limits can either cause protective systems to shut down large parts of the network or cause extensive damage to delivery equipment and in customers' facilities. Consequently, the electricity industry has created a set of strict operating procedures, which govern how generating units can be connected to the electricity grid, how the generator output can be raised or lowered (dispatched), and how they can feed electricity into the network.[xi]

Customer requirements vary seasonally, daily, and hourly, with the highest annual demand often being three or more times the lowest annual demand. To meet these requirements, producers or system operators will "dispatch" generating units based primarily on operating cost considerations, generally looking first to the most economic units for the expected load profile. These are usually sufficient to meet all requirements in periods of lowest, base demand (typically at night during spring and fall), but usually can only partially satisfy all requirements during periods of higher demand (typically daytime in summer and winter). For these higher, intermediate, and peak load periods, energy providers will employ units that are successively more expensive to operate.[xii] A diverse mix of generation ensures lower system cost without compromising reliability.

The specific generating mix of any utility or group of utilities will vary according to the generating resources available to them, and the different characteristics and economics of the fuel choices available.[xiii] In general, generation technology that is reliable and relatively inexpensive to operate will be preferred for base periods and more expensive technologies will be utilized at peak periods. Technology variety is important for the efficient functioning of any system, but any technology's use also turns on several fundamental elements of the supply process. Three of the more important elements are[xiv]:

1) *Capacity* – that ability of a system to meet the demand for power. Installed capacity then is the maximum instantaneous ability of a system at any time. To use an automobile analogy, capacity may be likened to the maximum power a car engine can produce on demand, although not necessarily demanded all the time.

2) *Load following* – the ability to respond to changes in demand (or load) over time to respond to customers' changing requirements as they turn on or off different appliances. This is like the vehicle's accelerator, which injects fuel into the car engine. The driver can adjust the supply of fuel to meet immediate velocity needs. Certain generation technologies are more applicable for load following than others. Peak load is the maximum demand – the demand at its highest – for instance during the evening when households are very busy.

3) *Energy* – the power delivered to satisfy the total of all customers' requirements multiplied by the time duration of this requirement. This can be roughly compared to the fuel in the vehicle's gas tank, except that electrical energy cannot be stored like fuel.

Applying the Basics to Wind

As with any technology, factoring wind generation into the mix depends on the engineering and economic realities of system design and operation, as well as the customer demand for specific technologies. It is therefore useful to review the characteristics of wind power in the context of the fundamental elements of an electricity system, described above.

Wind's contribution to capacity – the ability to operate on demand – is contingent on its availability (i.e. whether the wind is blowing). Wind cannot be turned on at will, so it is not dispatchable. It therefore cannot displace the need for and availability of generating sources that can be dispatched, as short-term fluctuations of wind power require that other generation facilities be available to increase or decrease system production very quickly. The significance of the stored hydro power across Canada may reduce this limitation, where wind systems can be backstopped by hydro. However, it should be noted that this will reduce the availability of hydro for other system needs – and so a case by case economic analysis is required.[xv] For the same reason it is difficult to attribute a value to wind's contribution to total capacity requirements. While this may be less of a challenge when wind is drawn from a range of dispersed sites, more operating experience is required in Canada to assess this possibility.

Wind's contribution to load following – wind cannot contribute to load following requirements because its intermittent nature makes it impossible to operate incrementally over time as wind turbines cannot be ramped up or down to meet instantaneous load changes the way other energy sources (like fossil-fueled plants) can be. In periods of non-steady winds, wind generators could exacerbate the difficulty conventional generators have with load following. A point worth noting here in wind's favour is that stronger winds and denser air (which means greater potential energy in the air) occur in winter when electricity demand is, on balance, higher across the country. Further operating experience with large utility-scale wind facilities (100 MW+) will deepen the appreciation of load following issues around wind power.

Wind's contribution to energy – wind is a good energy supply. The ability to predict the timing of that supply establishes the value of wind energy. If the best prediction is a yearly average, then wind energy will have a value consistent with yearly average energy value of the system. If wind energy production can be accurately predicted for any hour in the future, the value is that of the alternative displaced for that hour. While there are a growing number of forecasting tools available for wind energy, there will inevitably be variations from predicted occurrences that have been documented at 30% for next day forecasts.[xvi] Despite this, accurately forecasted wind generation can reduce the percentage of time that conventional high-cost dispatchable units with on-off cycling capability would need to operate – offering an advantage in terms of offsetting fuel costs, or possibly reducing environmental impacts (e.g., air emissions).[xvii]

When generating electricity, wind displaces other existing generation in the system; when it is not, other generation picks up the displaced load. The point where a utility's operating and ready reserve cannot replace lost wind energy along with other system disturbances (under most operating scenarios) is the point where wind has reached its penetration limit. For example, during a peak winter day with the loss of several large thermal units there may not be enough reserve capacity to replace the lost energy/ capacity. But under conditions where everything is running perfectly and a utility only loses its wind farms there probably is enough reserve. Adding extra resources to back up (firm) wind generation makes it less economical, and will affect its life-cycle environmental impacts as well. Existing generating systems in Canada and the United States maintain a level of reserve generation capacity required to support the overall system when existing generation or transmission capacities are forced or taken out of service. It is sometimes argued that this reserve capacity could be readily used to support the variability of wind generation.[xviii] However, this ignores the fact that reserve capacity is maintained as backup in anticipation of possible failures of generation or transmission equipment in the system. If dedicated instead to support the variability of wind generation, it would no longer be available for its prime task. To optimize system reliability, this back-up for wind must be found or built explicitly elsewhere in the system.

What Does This Mean for Wind in Canada?

This leads to the question as to what proportion of wind power existing systems and markets in Canada can absorb from a practical, operating and economic perspective. As there are few electricity systems in North America with any significant amount of wind[xix], there is little empirical experience to help quantitatively assess these penetration limits. This will change as the number of utility-scale wind projects increases and detailed operational knowledge and experience follows.

Based on members' extensive operating experience with many mixes of generation, and a review of the technical issues outlined above, CEA believes that the upper limit of what most systems in Canada can practically absorb wind is undetermined at this time. On a regional basis, (i.e. *per system* or power pool) the level may be more or less depending upon the mix of resources in that region. Systems that are dominated by hydro with significant reservoir capacity are in principle the most flexible to integrate wind power[xx], but even then, the grid characteristics may make it difficult or expensive to integrate significant quantities of new wind generation. This means that the correlation between wind availability and regional energy requirements, and therefore the ability to incorporate wind generation into the regional systems, will not be uniform across the country.

It should be noted that, if the price of wind power generation were to fall significantly, such that back-up power generation could be constructed to assure reliability, and yet a competitive market price could be maintained, then the gross amount of wind power added to the national generation mix could effectively be increased. There may be specific instances where wind penetration could be higher – such as in areas where there are significant hydro storage reservoirs, or where other innovative storage technologies can be combined with wind technology. However, where most conventional technologies are being considered for back-up, the environmental benefit that wind proponents claim as its particular value can be undermined.

For systems that currently have dispatchable gas on the margin, wind energy represents a substitute fuel with a value equivalent to the fuel displaced. The value will increase as wind energy prediction capabilities improve and wind facility operators or off-takers enter into the forward gas market with wind energy as the hedge mechanism.[xxi] Those involved in operating gas fueled generation facilities in an environment where fuel price does not automatically flow through to the end use customer (fuel cost adjustment clause) can use wind as an effective fuel cost management tool.

Conclusions

Canada possesses significant opportunities for the development of wind generation in terms of having:

- widely dispersed wind resources

- abundant agricultural and grassland sites near urban areas or existing transmission
- significant energy storage capability in some existing hydroelectric generation facilities (60% of Canadian installed capacity is hydro, but not all of it has significant storage)

Given these various factors, and the above analysis, CEA members believe that it is technically feasible to meet the CanWEA target of incorporating 10,000 MW of wind power into the system as a reliable source of energy. However, the economic feasibility of such integration will turn on a variety of factors, some of which cannot be fully assessed at this time. If governments wish to see such large scale wind development, they can send the price signals to stimulate it, and industry will respond with developments. In addition, these developments are most likely to occur provided that:

- the level of development proposed for any system is technically feasible or can be readily planned for future integration within that system
- a sufficient number of technically feasible sites can be identified in each region of Canada to cumulatively add up to the 10,000 MW target
- the long run real cost of natural gas remains at current levels or above into the future
- the costs of wind production continue to decline through technological improvements, an increased market pull for low emission technologies and/or sustained and meaningful support from government
- a domestic manufacturing base – that is cost competitive – is developed.

Canadian electricity companies are actively pursuing new and larger applications of wind technology across Canada today[xxii]. Wind farms represent a significant development in energy infrastructure in Canada and CEA member companies intend to be active in this development as they continue to meet the electricity needs of Canadians.

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[i] International Energy Agency, Executive Committee for the Implementation Agreement for Co-operation in the Research and Development of Wind Turbine Systems, 2003 Wind Energy Annual Report: http://www.ieawind.org/iea_wind_pdf/PDF_2003_IEA_Annual_Report/2003IEA_WindAR.pdf

[ii] Interconnection with the existing Canadian transmission grid or lack thereof will affect the potential development of wind generation in that system. Any system unconnected to the grid which carries a lighter load will necessarily be limited. For general discussion of transmission issues, see note ix below.

[iii] American Wind Energy Association, "Wind Industry Statistics" (2004): http://www.awea.org/faq/tutorial/wwt_statistics.html. See also AWEA, "Global Wind Energy Market Report" (March 2003): http://www.awea.org/pubs/documents/globalmarket2003.pdf.

[iv] CanWEA, "Wind Vision for Canada" (June 2001), p. 1; AWEA, "Global Wind Energy Report" (2002), p. 6; CanWEA, "Harnessing the Wind to Help Meet Canada's Kyoto Commitments" (2003).

[v] Canadian Wind Energy Association http://www.canwea.ca/QuickFacts.html. For an example of the cost of conventional technologies, see U.S. Department of Energy, Office of Fossil Energy, *Market-Based Advanced Coal Power Systems: Final Report* (May 1999), Table 9-3: http://www.fossil.energy.gov/programs/powersystems/publications/marketbasedsystems/sec9.pdf.

[vi] Hydro Québec, "Call for tenders for electricity from wind power: Hydro-Québec selects eight bids for a total of 990 MW", Press Release (October 4, 2004).

[vii] The Market Incentive Program, a $25 million federal government initiative to stimulate emerging markets for renewable electricity, and the Procurement of Electricity from Renewable Resources (PERR)

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program, which commits the Government of Canada to purchasing electricity from these sources for federal facilities, are examples of other incentives. Among provincial initiatives, the Ontario government recently enacted legislation which includes a series of tax incentives billed as "a long-term plan to promote environmentally friendly energy in Ontario."

[viii] It should be noted that the production cost of any generation technology is dependent on factors beyond the installed cost of the facility. In consort, tax treatment, project discount rate and facility capacity factor can easily swing unit production cost of any generation technology by a factor of more than two to one.

[ix] Although this paper focuses on generation issues, CEA wishes to comment also on the issue of transmission availability. Since the successful addition of large percentages of wind capacity to a system depends in large part on geographical dispersion of the wind capacity, then the success of wind (and in fact any new generation project) is going to depend on adequate transmission. New AC transmission costs on average Cdn$480,000 per km, so if wind development depends on significant new transmission, then it is possible that wind will lose any cost advantage that it now has. (On the cost of transmission, see the estimates in Joseph DeCarolis and David Keith vs. Mark Jacobson and Gilbert Masters, "The Real Cost of Wind Energy," *Science* 2001:294, 1000-1003 and the "Debate Responses" that follow. Average of $310,000 (US) per km AC transmission, p. 1001; estimate of 0.000345 US¢/kWh/km for HVDC transmission, pp. 11 and 16 of the "Debate Responses" section):
http://wpweb2k.gsia.cmu.edu/ceic/pdfs_other/Science_debate_on_wind_2001.pdf.)
The problem of wind and transmission is not simply a problem of access to existing transmission lines, but also of the capacity available on existing lines. It is not enough for a new wind site to have ready access to existing transmission, if the lines are already operating at maximum capacity. And, on the whole, the North American transmission system is already overloaded, with bottlenecks in a number of places and persistent problems with transmission congestion. However, an inadequate transmission grid is not the particular problem of new wind generation. Depending on its location, any new generation is likely to suffer, or exacerbate, the same transmission problem.

[x] Solutions for this problem are already in the developmental stage. The Iowa Storage Energy Project is working on a project that would use compressed air stored in underground aquifers to store energy harnessed from the wind by 2008: "Iowa works to store wind power in underground aquifers", *Quad-cities Online*, January 6, 2004.

[xi] These operating procedures are coordinated through the North American Electricity Reliability Council (NERC) and enforced by transmission system operators. Failure to adhere to the operating procedures could result in a generator being disconnected from the system.

[xii] Another type of generation known as spinning reserve must be operated throughout the day and night to handle shorter term variations from the hourly expected averages.

[xiii] In general terms, the table below sets out the "standard" mix of conventional technologies:

Capacity Factors	**Load**	**Resource**	**Typical Economic Characteristics**
Very high CFs	Base	Coal/Nuclear/Hydro	High capital cost Low operating cost
Medium CFs	Intermediate	Gas/Coal/Hydro	Medium capital cost Medium operating cost
Low CFs	Peaking	Gas/Oil/Pumped Storage	Low capital cost High operating cost

[xiv] There are other important elements, including operating reserves (spinning and supplementary (also known as "ready")), environmental operating constraints (e.g. emission limits), voltage control and frequency control and other factors that are important for operating generation facilities.

[xv] Since the useful capacity of wind power during peak periods is very low, the development of wind power clearly has hidden costs in terms of additional backup capacity. A recent Hydro-Québec study concluded that wind power will have a significant effect on river flows when hydropower is the backup option. Simulations for wind/hydro combinations were carried out using real data on electricity demand, hourly wind speeds, hydraulic flow and parameters of wind turbines. The simulations raise two main issues: the increase in short-term fluctuations and the reduction of flow during the dry summer period. These impacts

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are directly proportional to the size of the wind power development, relative to the production of the hydro base case. In Québec, with more than 30,000 MW of hydro capacity, it means that installing a few hundred MW of wind power would not have a significant impact on river flows. Installing a few thousand MW could have such impacts: Claude Belanger and Luc Gagnon, "Adding Wind Energy to Hydropower" *Energy Policy* November 2002, vol.30, no. 14, pp. 1279-84.

[xvi] James Caldwell, Policy Director, AWEA, "Managing Regulatory Issues in Grid Access and Interconnection Agreements", paper presented at Infocast Financing Wind Power Projects Conference (December 3-5, 2003, New York).

[xvii] Michael R. Milligan, NREL, "Modeling Utility-Scale Wind Power Plants, Part 2: Capacity Credit", March 2002. NREL/TP-500-29701, p. 50.

[xviii] For conclusions favourable to higher wind penetration, see the study funded by CanWEA prepared by David Milborrow of D M Energy: Impacts of Wind on Electricity Systems with Particular Reference to Alberta.

[xix] New York State Energy Research and Development (NYSERDA), "The Effects of Integrating Wind Power on Transmission System Planning, Reliability, and Operations, Draft Report on Phase 1: Preliminary Overall Reliability Assessment" (January 8, 2004). At 3.1.1 "World Experience with Wind Integration: Example Systems" the study notes that the US state of New Mexico exhibits significant wind penetration (14%), although the major wind farm in New Mexico has just entered commercial operation and thus the public utility (Public Service of New Mexico) has minimal operating experience.

[xx] Wind energy complements large-scale hydro by leveraging the flexibility of a hydro facility. Large hydro facilities can store energy by allowing reservoirs to grow when wind power is available and can fill the gap by releasing flows when winds are not blowing. See also: Belanger and Gagnon *supra* note xv.

[xxi] In some jurisdictions (such as Texas), where costs of wind are competitive with electricity produced from more common (natural gas) sources, some customers are signing contracts for wind generation as a "hedge" against future price increases in generation produced from these fossil fueled sources: Mark Bolinger & Ryan Wiser, "Quantifying the value that Wind Power provides as a hedge against volatile Natural Gas Prices", paper presented at WindPower 2002 (2-5 June 2002, Portland, Oregon), where the hedge value is estimated at ~0.5 US¢/kWh.

[xxii] The Appendix describes a number of wind analysis studies presently underway at CEA member companies.