How wind turbines are not generating green energy: An economic review of the Ontario Green Energy and Green Economy Act

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Abstract

The Ontario Government passed the Ontario Green Energy and Green Economy Act in 2009. The Act promoted wind turbines and solar panels as a major component of the energy supply for the Province of Ontario as a replacement for coal-fired electricity generation plants. This article provides an economic assessment of the rationales that were offered for this policy, specifically, that the Act would help the Government of Ontario reduce the province's reliance on fossil fuels, reduce carbon emissions, and stimulate the economy through the creation of jobs. The effects of the policy on the cost of electricity in the province are also considered. The analysis concludes that the Act will not reduce the Province of Ontario's reliance on fossil fuels due to the inefficiency and unpredictability of wind turbines, ultimately leading to the need to use energy from more readily available sources of electricity such as gas. The need for fossil fuel backup also limits the potential to reduce the green house gas emissions.

Keywords: Ontario Green Energy and Green Economy Act (2009); renewable energy; economic review

Introduction

The Ontario Green Energy and Green Economy Act was passed in 2009. The goal of the Act was to eliminate production from coal-based electricity and replace it with electricity produced by wind turbines and solar panels. George Smitherman, Minister of Energy and Infrastructure when the act was introduced, was quoted as saying (Government of Ontario 2009):

Ontario wants green energy business. These regulations will help ensure industry and municipalities that jobs will be created, investment is committed and that the renewable energy industry grows across the province.

The pursuit of green jobs has not been limited to Ontario. Many jurisdictions have developed policies to promote economic development through the promotion of non-fossil fuel based energy production systems; however, a growing body of evidence, which will be discussed in this article, suggests that these efforts have yielded, at best, limited social, economic and environmental benefits. This objective of this article is to analyze the Green Energy Act and Green Economy Act in terms of: a) its effectiveness in

reducing Ontario's reliance on fossil fuel based energy systems; (b) the net impact of the Act on provincial green house gas emissions from electricity production; and c) the net impact of the Act on the economic effects of increased electricity costs.

History

The Government of Ontario has traditionally organized electricity as a public utility. According to Canada Energy (2012), the Ontario Hydro Commission (most commonly known as Ontario Hydro), has been the main institution providing electricity in Ontario since it was founded 1906. Hydroelectric generation satisfied the needs of Ontarians until the 1950s, when the first coal-fired generating stations were developed in Ontario (Canada Energy 2012). Ontario's nuclear power program began when the Bruce Nuclear Plant opened in 1968. The Independent Electricity System Operator (2006) reports that three modes of electricity production (hydroelectric, coal, and nuclear) powered Ontario's economic growth during the 20th century, but recently, oil and natural gas have become more important.

Historically, wind, solar, biomass, and landfill gas made up almost an insignificant portion of Ontario's total electricity production capacity. **Table 1** shows the breakdown of electricity supply in Ontario in 2006.

Table 1. Existing installed generation resources in 2006. The major fuel types used for electricity generation in Ontario are nuclear, hydroelectric, coal, and oil/gas.

Adapted from *The Independent Electricity System Operator* (2006).

Fuel Type	Total Capacity (MW)	Number of Stations
Nuclear	11,419	5
Hydroelectric	7,768	68
Coal	6,434	4
Oil/gas	5,103	22
Wind	395	4
Biomass/Landfill gas	70	4
Total	31,189	107

The Government of Ontario restructured many aspects of the Ontario electricity system during the 1990s. Howlett (2008) and Canada Energy (2012) explain that the Crown Corporation began to experience difficulties around this time. Aging facilities, lack of competition, and the approximate \$10 billion dollar cost overrun of the Darlington Nuclear Station resulted in a 30-40% increase in retail electricity prices in just four years. These events led the Conservative Party of Ontario, elected in 1995 and in 1998, to put forward a plan for the establishment of wholesale electricity in the province and the deregulation of the electricity market (Canada Energy 2012). As a result, the energy sector was split up into several different entities and electricity was sold on a market for a spot price. A widely-cited study by Trebilcock (2004) explains the method in which the spot price was determined. The electricity market opened to both wholesale and retail price competition. In this market, the wholesale electricity price varied every five minutes in response to changing levels of demand and supply. Retailers were free to enter into fixed price contracts with a retail intermediary or purchase with their local distribution utility paying the average hourly spot market price, the spot price being the average hourly wholesale price. According to Dewees (2005), Ontario Hydro's average total cost was around 4.5 cents per kWh; however, when the market first opened on May 1, 2002, Ontario struggled with several nuclear plants going out of commission as well as record drought and heat waves. In July 2002, the price of electricity rose to 6.2 cents per kWh and reached a peak price of 8.3 cents per kWh in September of the same year. Growing public displeasure over high prices eventually resulted in price freezes for consumers at around 4.7 cents per kWh (Dewees 2005).

High retail prices coupled with the infamous blackout of 2003 led to an investigation by the Electricity Conservation and Supply Task Force. That Task Force (2004, p 4-5) concluded that:

The market approach adopted in the late 1990 needs substantial enhancement if it is to deliver the new generation and conservation Ontario needs, within the timeframes we need them. Major changes in the energy economy and in public policy have undermined the viability of the original market design.

We fully support the principles of competition and consumer choice. Competition and choice are essential if we hope to achieve an efficient and responsive electricity sector. Ontarians need comfort that the looming supply gap will be addressed, but they also need comfort that the electricity system that is developed going forward remains workable, fair and efficient. The action plan we are proposing is designed to support and accelerate the development of a competitive power supply market in Ontario.

In October 2003, the Conservative government was replaced by a Liberal government.

Figure 1. Projected share of electricity supply for Ontario by source. 2003 generation is the amount of energy supplied by various sources. Distribution of supply sources for 2010 and 2030 are based on the Long Term Energy Plan (Ministry of Energy of Ontario 2010).

Reproduced with permission from the Ministry of Energy of Ontario (2010).

Ontario Green Energy and Green Economy Act

The Ontario Green Energy and Green Economy Act (2009) was intended to shift energy supply away from coal-based electricity and replace it with wind energy, solar energy, and bioenergy. **Figure 1** shows Ontario's energy supply in 2003 and its projected energy supplies in 2010 and 2030. The chart shows that coal was responsible for 25% of Ontario's energy supply in 2003. The Government of Ontario (2006) claims that all remaining coal plants will be eliminated by 2014 and the energy that they currently supply will be replaced by green energy in the following

proportions: 0.3% will be replaced by bioenergy, 1.5% by solar energy, 10% by wind energy, and 14% by conservation (Ministry of Energy of Ontario 2010). While conservation efforts are important, they are not forms of energy and do not contribute to the total supply of energy available.

Figure 1 implies that the 25% of energy currently supplied from coal will instead be supplied by renewable energy in 2030. If we take the 2030 projected generation provided by the Government of Ontario and remove conservation to show only supplies of energy that are producing electricity, we can calculate that wind energy, solar energy, and bioenergy will only support half of the energy produced by coal. It is probably, therefore, that the other half will be shifted into more nuclear energy.¹ If this is the case, then the 2030 projected generation should include that nuclear energy will supply 53% of Ontario's total energy in 2030, as opposed to the 46% currently being reported.

Feed-in tariffs

A system of fixed producer prices known as feed-in tariffs (FIT) was established for various modes of electricity production to be promoted under the Act. A feed-in tariff is a guaranteed price paid to renewable energy producers by the province (Ontario Power Authority 2010). The renewable energy sources being implemented are not economical at market price; thus, feed-in tariff contracts are priced around the cost of production (Ontario Power Authority 2010). The government then regulates which sources of electricity are put into the grid. The Ontario Power Authority (2010) has stated that renewable energy shall receive preferential treatment, meaning that it is put into the grid over sources such as nuclear energy, hydroelectricity, and natural gas. For example, the Ontario Power Authority (2010) is offering contracts for wind turbines, which give producers of wind energy a guaranteed price of 13.5 cents per kWh for 20 years. The Ontario Power Authority (2010) has also stated that solar panels, depending on the type, will have a value ranging from anywhere between 44.3 cents per kWh to 80.2 cents per kWh for 20 years. The goal of the system is to guarantee producers long-term price stability (Ontario Power Authority 2010). By doing this, the government is making producers profitable and allowing them to continue to produce forms of energy that would otherwise not be produced at market prices.

Wind Energy

Reasons for wind energy

The number of wind turbines in Ontario has increased from 10 to 700 since 2003 (Government of Ontario 2010). Three rationales have been offered by the Government of Ontario for its policy promoting wind electricity: 1) wind energy is a renewable source of energy produced locally and will reduce dependence on fossil fuels; 2) wind energy is environmentally-friendly and reduces carbon emissions; and

3) wind electricity is better for the local economy and will create jobs (Government of Ontario 2010).

Wind as a renewable source of energy and energy security

Wind energy is not a fossil fuel-based form of energy and is therefore expected to reduce dependency on fossil fuels (Government of Ontario 2010). According to Windustry (2012):

Wind turbines diversify our energy portfolio and reduce our dependence on foreign fossil fuel. Wind energy is homegrown electricity, and can help control spikes in fossil fuel cost.

Monthly Capacity Factors of Wind Turbines in Ontario

Figure 2. The percentage of total installed capacity produced by wind turbines in Ontario from 2007-2011.

Reproduced with permission from Luft (2011).

Installed capacity is defined as the maximum amount of electricity (measured in megawatts) that wind turbines can produce. The Canadian Wind Energy Association (Canwea) (2011) report estimates that there are currently 5,265 MW of installed capacity for wind turbines in Canada, and approximately 1,969.5 MW of installed capacity in Ontario. However, a study by Trebilcock (2009) showed that in Ontario, the average wind turbine only runs at 25% installed capacity. While renewable energy is naturally replenished, no electricity is produced when there is no wind. A study by Results by Luft (2011), shown in **Figure 2**, also support these conclusions. When energy demand is at its highest, typically in July due to hot weather and high air conditioning demands, wind power is at its lowest level of production (10% of installed capacity), meaning that other forms of back-up electricity are necessary to keep power going.

According to Bell (2011), Texas has the highest potential for wind energy of all American states; however, in Texas, wind energy has huge volatility with respect to capacity utilization, which results in an average capacity utilization of only 16.8%. Bell (2011) also showed that the capacity of wind turbines is low during peak demand times. Only 20% of turbine capacity is available during peak

demand times (around 5:00 PM), while the average supply at off-peak times is about 40%. In a similar study, Derbyshire (2008) reported that the United Kingdom experiences the lowest levels of energy production (around 1.6% capacity) from wind turbines during the coldest months, due to freezing from low temperatures. Furthering the problem, a study by Gallant (2011) showed that many of the turbines had to be heated with natural gas and coal to reboot them, ultimately resulting in the use of more electricity than the turbines actually produced.

To tie these findings into the Ontario framework, Hughes (2012) used an electricity supply and demand framework to explain the indirect effect of wind turbines on fossil fuel usage. As demand for electricity increases, plants with higher marginal costs start to generate more electricity. Generation technologies can be ranked from low to high marginal cost: a) geothermal (the lowest cost), b) nuclear, c) hydro, d) advanced coal, e) conventional coal, f) biomass, g) gas combined cycle, h) gas turbine, and i) pumped storage hydro (the highest cost). During off-peak times, sources such as nuclear, hydro, and coal with carbon capture and storage are used to provide base load demand. As demand increases during peak hours, sources such as older coal plants, gas combined cycles, and gas turbines are used to match the higher demand. Hughes' (2012) findings coincide with Bell's (2011) study in that wind turbines produce the most energy during off-peak times. As a result of increased reliance on wind turbines, revenue from base load generation sources such as nuclear energy, hydroelectricity, and coal with carbon capture and storage will be reduced (Hughes 2012). Because revenue is no longer high, investment in nuclear energy, hydroelectricity, and coal with carbon capture and storage will decrease and instead be diverted into gas combined cycle plants and gas turbines, ultimately making Ontario more dependent on sources derived from fossil fuels.

Furthermore, Hughes (2012) reported that there are very high capital costs for constructing wind turbines. According to the Independent Electricity System Operator (2011), there are 34,079 MW of total energy capacity in Ontario, and according to Canwea (2011), there are 1,965.5 MW of installed wind energy capacity in Ontario. Using 2010 values, there are 700 wind turbines in Ontario, meaning that one would have an average capacity of just under 2.8 MW. If the average wind turbine only runs at an average of 25% installed capacity, the average energy production of one wind turbine would be 0.7 MW. To accomplish production equal to 12% of Ontario's 2011 energy demand (Ontario's goal was 12% wind production for 2030's energy demand), 4089.48 MW of energy would be required from wind turbines. Thus, if one wind turbine produced 0.7 MW on average per year, Ontario would require 5,842 wind turbines to meet 12% of Ontario's 2011 energy demand. Canwea (2011) estimated that it would cost around CAD 3.1 billion to build a sufficient number of wind turbines to supply 1,267 MW of energy, which means that it would require approximately CAD 40 billion to build enough wind turbines to satisfy 12% of Ontario's 2011 energy demand.²

This is vastly more than the cost of the Bruce nuclear plant, which was reported by Green Peace (2008) to cost around CAD 7.8 billion and according to Bruce Power (2012), produces between 4,700 and 6,300 MW per year.

These calculations show not only show the high cost of energy production by wind turbines, but also the undependability of wind turbines due to energy production during off-peak times and reliance on backup power. As shown by various studies, wind turbines discourage investment into cleaner sources of production such as nuclear energy, hydroelectricity, and clean coal, and instead divert investment into fossil fuel-based production systems such as gas and oil. Due to the high volatility of wind power capacity utilization, it is clear that wind turbines will not provide Ontario with a reliable source of energy nor will they reduce Ontario's reliance on fossil fuels.

Wind as a means of environmentally-friendly energy production

The second argument for wind electricity provided by the Government of Ontario (2010) is that wind electricity is a green technology, which means it is better for the environment and better for our overall health. The European Wind Energy Association (2012) states that:

The large-scale use of renewable energy sources is essential if the necessary reductions in carbon dioxide and other emissions from electricity generation are to be met and if sustainable development and sustainable growth are to be achieved.

Although the European Wind Energy Association (2012) reports that wind turbines cause virtually no carbon emissions and are therefore essential to reducing greenhouse gases, Trebilcock (2009) argues that there is no evidence to support this claim. Wind-intensive countries such as Denmark and Germany have been unable to close any coal-fired plants due to the need of backup power when wind and solar plants are not producing. Given that wind turbines only produce at around 25% of total capacity, power production from fossil fuel sources will always need to be in place as a substitute, which would offset any reduction in greenhouse gases (Trebilcock 2009). As stated earlier, Hughes (2012) showed that investment into wind energy is likely to reduce investment into clean energy sources such as nuclear power, hydroelectricity, and clean coal. Operations such as gas combined cycle plants and gas turbines, which rely on fossil fuels as energy sources and contribute to the production of greenhouse gases, will be more highly used (Hughes 2012). Thus, the net result may be no change or even an increase in greenhouse gas production as a result of wind turbines.

To contrast the feed-in tariffs associated with wind turbines and other forms of green Energy in Ontario with a carbon tax, Ayres et al. (2004) estimated the cost of coal if a given carbon tax was added to its price. According to the study, the price of coal was between 4.77 and 5.93 cents per

kWh as a base rate, and the addition of a \$15 per tonne carbon tax increased the cost to between 6.12 and 7.28 cents per kWh. This shows that coal energy with a carbon tax would still be cheaper than subsidizing wind energy, and possibly more effective at reducing carbon emissions.

The Ontario Ministry of Energy (2011) has reported that by shutting down coal plants, it will save CAD 4.4 billion dollars per year in health care costs. In contrast with the government's claim, a study by McKittrick (2011) found these claims to be unwarranted. The study showed that tremendous efforts have been put into place to install advanced emission control devices, which have resulted in a dramatic fall in air pollution since the 1970s and 1980s. According to the Government of Ontario (2011), Ontario coal plants released 699 metric tons of particulate matter smaller than 2.5 microns (PM 2.5) in 2009, which caused 316 deaths, 440 hospital admissions, 522 emergency room visits and 158,000 minor illnesses each year. McKittrick (2011) compared this claim to unpaved roads in Ontario, which put out 90,116 metric tons of PM 2.5, a value that would equate to approximately 40,739 people being killed per year from unpaved roads. Following the same reasoning, the study also concluded that 502 people per year would die from wood-burning stoves in Ontario.

Beyond greenhouse gases, wind turbines also have other environmental impacts. For example, there has been strong criticism against wind turbines for their negative impact on wildlife. Although more studies need to be conducted, there is significant evidence that wind turbines are interfering with migratory patterns and negatively affecting ecosystems for many birds, owls, and bats (Blackwell 2010). Along with wildlife interference, wind turbines take up anywhere from 100 to 1,000 times the land area compared to other sources of energy production, which may result in the destruction of the ecosystems and habitats of wildlife (Trebilcock 2009). Large land coverage has also been reported to negatively affect the welfare of those who live near wind turbines due to their noise, which is frequently cited by residents as a cause of sleep disturbance and irritation (Devine-Wright 2005).

Local economy and job creation

The third argument used as a rationale for wind turbines is that wind power is produced locally and thus better for the Ontario economy. The Ministry of Energy (2011) stated that the Green Energy Act has created 20,000 new jobs and that another 30,000 jobs would be created by 2012. However, a Spanish study reported that "for every job created by state-funded support of renewable, particularly wind turbines, 2.2 jobs are lost ... [and] ... each wind industry job created cost[s] almost \$2 million in subsidies" (Alvarez et al. 2009, cited in Trebilcock 2009). The Canadian Press (2011) also predicted that wind energy would result in job losses in Ontario, given the higher cost of electricity production described below.

The Ministry of Ontario (2010) stated in their long term energy plan:

Over the next 20 years, prices for Ontario families and small businesses will be relatively predictable. The consumer rate will increase by about 3.5% annually over the length of the long-term plan. Over the next five years, however, residential electricity prices are expected to rise by about 7.9% annually (or 46% over five years).

A study by Gallant and Fox (2011) concluded that these price increases have been underestimated due to numerous cost emissions, including the cost of gas when solar and wind power is not producing and failure to consider that conservation is not a form of energy supply. Thus, Gallant and Fox (2011) concluded that the average yearly household electricity bill would increase from CAD 1,700 to CAD 2,500 by 2015 and CAD 4,100 by 2030, increases of 65% and 141%, respectively. The price increase would also have negative effects on business and employment.

Current surplus of electricity in Ontario

Earlier in this article, implications of the majority of energy production by wind turbines occurring during off-peak hours were discussed. This also contributes to Ontario's surplus base load generation. According to the Office of the Auditor General (2011) Ontario's base load fleet includes nuclear units, certain hydro stations and now intermittent renewable energy sources such as wind. Ontario did not have any surplus base load generation days from 2005 to 2007, but had 4 days in 2008, 115 days in 2009, and 55 days in 2010 due to an increase in wind power and a drop in electricity demand (Office of the Auditor General 2011).

Figure 3. Electricity charge paid by Ontario residents compared to the export price received by Ontario from other jurisdictions (in cents per kWh).

Reproduced with permission from The Auditor General of Ontario (2011).

Surplus electricity is difficult to handle as storing power is uneconomical; thus, exporting surplus power is the most common and preferred way to deal with power surpluses (Office of the Auditor General 2011). Since 2006, Ontario has been a net exporter of power. The price Ontario receives for exported power is between 3 and 4 cents per kWh; however, the rate that Ontario consumers pay for their electricity is more than 8 cents per kWh. **Figure 3** shows the difference between the prices paid for electricity by Ontario residents compared to the export prices received by the province. From 2005 to 2011, Ontario received CAD 1.8 billion less for its electricity exports than what it charged electricity ratepayers of Ontario (Office of the Auditor General 2011).

As more investments into renewable energy occur, mainly wind turbines, the surplus base load generation will continue to increase significantly over the next decade. The report compared this situation with Denmark, which relies heavily on wind power and exports large amounts of surplus power to Norway and Sweden. Since there are few options, Ontario could reduce hydro power by diverting or spilling water; however, hydro power is often one of the cheapest and cleanest forms of energy and reducing this renewable energy to make room for wind and solar energy would be counterproductive. Reducing nuclear power is also an option, but is viewed as a last-resort option as nuclear units are highly costly and are designed to run constantly at maximum capacity. The only other option would be to remove wind turbines from the line; however, due to the feed-in tariff contract specifications, the wind and solar generators would still be paid.

According to the Auditor General's Report (2011), 86% of wind power in 2010 was produced on days when Ontario was already in a net export position. As a result, the Green Energy Act is creating an energy surplus in Ontario where the province is paying more to produce energy than they are receiving to sell it. Thus, the Green Energy Act is not only counterproductive in that it is reducing jobs due to higher production costs, but it is also raising electricity costs, hurting business profitability, and reducing consumer purchasing power.

The Bootleggers and Baptist Model: A Model for the How the Green Energy Act Has Influenced Ontarians

Buck and Yandle (2001) discussed the way in which two separate interest groups can work together to pursue a common goal. Their study provides a framework for how governments take a moral highground on political decisions, which negatively effect policy changes yet influence voters. The phrase 'bootleggers and baptists' originated in the southern United States during the prohibition era. The bootleggers and baptists would work together to support the prohibition of alcohol. The bootleggers would lobby the

government through backroom deals as their profit margins would increase from the ban of alcohol. The politicians would persuade the public by taking the moral highground of the baptists, thus creating an incentive for the bootleggers and baptists to work together. This model of bootleggers and baptist is applicable to the Green Energy Act in Ontario. Buck and Yandle (2001) discuss the way in which the environmental movement has become a new fundamentalist belief. Parallels to the baptists and bootleggers models are drawn in which environmentalism, or what is perceived to be environmentalism, has taken precedent over factual results. The government of Ontario has dismissed the statistical and financial results of their policy in order to influence votes by playing on their voters' beliefs.

Samsung is an example of one of the many organizations that would profit from the Green Energy Act. Renewable Energy World (2010) reports that Samsung C&T Corporation has invested CAD 7 billion to generate 2,500 MW of wind and solar power in Ontario. The Ontario government has committed to providing assistance in securing the land and purchasing the produced electricity from Samsung C&T Corporation.

A second example is The Toronto Renewable Energy Co-operative (TREC) and WindShare, two groups who work together according to the baptist and bootlegger model. TREC (2012) reports that The Toronto Renewable Energy Co-operative is a non-profit, environmental co-operative that develops renewable energy projects and educates Ontarians about renewable energy. TREC has been influential in creating and designing some of the critical policies in the Green Energy Act, such as feed-in tariffs. WindShare (2012) reports that they are a for-profit wind turbine company that was independently launched from TREC in 2002. According to Windshare (2012), the company submitted a proposal for rights to construct a 20 MW wind farm east of Kincardine, Ontario in which the government would pay Windshare above-market prices for its electricity generation. According to TREC (2011), many of the members on Windshare's Board of Directors also hold important roles on the Board of Directors for TREC. Many of these members have also been influential decision-makers in government policy and have held key roles in the creation of feed-in tariffs and the Green Energy Act. Buck and Yandle's (2011) model explains how the Green Energy Act is being marketed to the public by the Government of Ontario as they gain influence over voters by taking the moral highground on environmentalism, while businesses such as WindShare and Samsung benefit from hefty profits.

Conclusion

This article shows that because of the intermittency of wind turbines, as well as the majority of wind generation occurring during off-peak hours, the subsidization of wind turbines as part of the Green Energy Act is largely inefficient. The feed-in tariff system will end up replacing

nuclear and/or hydro generation instead of replacing gas-fired generation with wind and solar generation. Because of this, Ontario's Green Energy Act will make Ontario more reliant on fossil fuels for the use of electricity and will not reduce Ontario's carbon foot print. Ontario will also face a net loss of jobs and higher rates for consumer electricity. If the purpose of the Green Energy Act is to improve energy security, improve the overall health and environment of Ontarians, and create more jobs in Ontario, then it remains far from accomplishing that purpose.

Endnotes

1. The projected generation was 2030 without the inclusion of conservation was calculated as follows: first, all forms of energy (bioenergy 1.3%, solar 1.5%, gas 7%, wind 10%, conservation 14%, water 20%, and nuclear 46%) were added together to achieve 99.8% (for simplicity, this was rounded to 100%, or 100 units). Since conservation, which represents 14% (14 units), is not a form of energy, this was removed from the total to yield 86 units. Assuming a new total of 86 units, the redistributed percentage for each energy supply was found by dividing by 86. For example, for nuclear energy: $46/86 \times 100\% = 53.4\%$.

2. If there are 700 wind turbines in Ontario and 1,965.5 MW of installed capacity, the average wind turbine has a capacity of $1,965.5/700 = 2.8$ MW. However, given that the average turbine only runs at 25% capacity, each wind turbine would produce $2.8 \text{ MW} \times 0.25 = 0.70$ MW of energy. If 34,079 MW is Ontario's total electricity production and wind needs to cover 12% of this energy production, wind energy would need to supply $34,079 \text{ MW} \times 0.12 = 4,089.48$ MW. To achieve this production with the average wind turbine producing 0.70 MW of energy, Ontario would require a total of $4,089.48 \text{ MW}/0.7 \text{ MW} = 5,842$ wind turbines. If the cost of 1,267 MW of installed capacity is \$3.1 billion by an average efficiency of 25% is assumed, then the true cost of producing wind energy is \$3.1 billion per $1,267 \times 0.25 = 316.75$ MW of energy. Ontario's total need of 4,089.48 MW is $4,089.48 \text{ MW}/316.75 \text{ MW} = 12.9$ times greater than 316.75 MW, giving a total cost of $\$3.1 \text{ billion} \times 12.9 = \40 billion. Thus, to achieve 4,089.49 MW (12% of energy production), the total cost would be \$40 billion.

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