Lessons learned from a decade of promoting renewable energy in Ontario

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1 Introduction

Ontario has undergone a number of major changes in the management of its electricity sector, including the development of significant nuclear generating capacity in the 1960s through the 1980s, and its experiment with deregulation in the late 1990s. From around 2004 to 2007, it began another such experiment, with the development of a new Integrated Power System Plan (IPSP), a 20-year plan to refurbish existing generating assets, invest in new assets, overhaul governance, and modernize the grid. Of particular note was the plan to dramatically increase the contribution of renewable energy sources to electric supply in the province. By 2025, the IPSP aimed to have about one-third of total capacity, or roughly 15,700 MW, met by renewables. This commitment was augmented in the 2013 Long Term Energy Plan (LTEP), which aims to have 20,000 MW of renewable generation capacity on-line by 2025, including over 10,000 MW from non-hydro sources (primarily wind and solar). I focus on these "new" renewables in this commentary.

In response to these targets, the Ontario Power Authority began an ambitious program to source new renewable energy supply. From about 2005 to 2008, it procured renewable energy via a competitive process, by soliciting bids to supply renewable energy in response to calls for proposals. Then, starting in 2006, Ontario launched the Renewable Energy Standard Offer Program (RESOP). The RESOP was aimed especially at encouraging participation by smaller providers, by providing standardized contracts for renewable energy that reduced transaction costs significantly. Like the European programs on which it was modeled, the RESOP also differentiated tariff rates by energy source, to encourage generation from resources that were otherwise non-competitive. More recently, following closely on the design of Germany's longstanding feed-in tariff program for renewable energy, Ontario announced a feed-in tariff program in October 2009, as part of the *Green Energy and Green Economy Act*. The program built on the RESOP by providing transmission system access (the RESOP provided access to the distribution grid only), removing caps on project size (the RESOP capped projects at 10 MW), and enhancing tariffs for renewable energy (Yatchew and Baziliauskas, 2011; Mabee et al., 2012).

As intended, these programs have quickly transformed the province's electricity system. From a small base at the end of last decade, new renewable electricity generating capacity in Ontario has grown to nearly one quarter of total capacity, as shown in Figure 1.[1] Ontario is now the leading jurisdiction for wind and solar energy in Canada, as shown in Figure 2, both in terms of the share of total capacity as well as in absolute terms. In 2015, Ontario's wind capacity is about 13% of total generating capacity, not far behind Germany's

[1]The Ontario Power Authority reports that as of the third quarter of 2014, 8,375 MW of wind and solar power are either in operation or under development (with a contract secured), and as of 2015, 6,250 MW of wind and solar are operational. The IESO reports that total system capacity is 34,780 MW. See: `http://www.powerauthority.on.ca/current-electricity-contracts` and `http://www.ieso.ca/Pages/Power-Data/Supply.aspx`. A portion of the wind and solar power under contract is not yet built and so does not appear in Figure 1.

21% share (but still less than half of Denmark's world-leading 29%).[2] Further expansion of renewable energy in the province will occur as procurement under the FiT program continues, and existing applications are processed, and as new renewables are sourced under a newly established competitive procurement protocol.

While all three renewable energy programs have contributed to the dramatic increase in renewable energy supply in the province, by far the greatest impact has come from the feed-in-tariff program. Data from the Ministry of Energy and the Ontario Power Authority show that competitive procurement of renewable energy, which took place from 2005-2008, resulted in about 1,500 MW of capacity additions. The RESOP program added another 1,000 (Ontario Auditor General, 2011). The feed-in-tariff program was responsible for adding about 6,000 MW of new capacity (contracted or in service) to date, and as such has contributed by far the most to total renewable supply in the province.

The introduction of new renewable supply in Ontario is coincident with the closure of all of the province's coal-fired generating units, a move which dramatically reduced greenhouse gas emissions in the electricity sector. This move has been called the most significant greenhouse gas policy on the continent,[3] and was facilitated in part by the increase in renewable supply beginning in 2005 (which replaced some of the supply).

Yet despite these notable successes of the Ontario feed-in tariff program, it was dramatically scaled back after only three years. Procurement under the feed-in-tariff from 'large' projects, which made up the majority of capacity additions under the FiT, ended with a directive from the Ontario Minister of Energy on June 12, 2013.[4] Likewise, capacity from 'small' projects, including especially solar PV installations, will likely begin to be sourced by net metering in coming years.[5] In this document, I reflect on what can be learned from Ontario's decade-long experience with aggressively promoting renewable energy.[6]

2 Lessons learned

2.1 Overall cost of procuring renewables was higher than it needed to be

By providing payments to renewable electricity generators that are up to 10 times larger than costs of securing electricity from other sources, the FiT program increases the cost of electricity in the province. Figure 3 shows the cost of electricity in the province since 2006 has increased from about $50/MWh in 2006 to about $90/MWh today, an increase of about 80% (much larger than cost inflation for other consumer goods) (see also McKitrick and Adams, 2014).

It is important to clarify that only a portion of this increase in electricity costs is attributable to renewable energy procurement. Dachis and Carr (2011) estimates that the overall cost of the program is about $1.5 billion annually (for roughly 8,000 MW of renewable supply). Similarly, Böhringer et al. (2012) estimate that the program imposes a cost of $1.1 billion annually. These estimates work out to about $7 to 10/MWh, or only a portion of the overall cost increase shown in Figure 3. Ontario's auditor general estimates that the FiT is responsible for over $2 billion annually in Global Adjustment payments (the GA is one of the two components of the electricity commodity price in Ontario) (Ontario Auditor General, 2011).[7] McKitrick and Adams (2014) estimate that a significant fraction of the recent increase in the Global Adjustment is due to

[2]See https://www.energy-charts.de/power_inst.htm and http://www.ens.dk/en/info/facts-figures/key-figures/danish-key-figures.

[3]See http://www.energy.gov.on.ca/en/clean-energy-in-ontario/.

[4]See http://www.powerauthority.on.ca/sites/default/files/MC-2013-1450-DirectionRenewableEnergyProgram.pdf.

[5]The 2013 Long Term Energy Plan discusses the idea of converting the existing microFiT program into a net metering program.

[6]I focus on economic issues associated with the program, since social and political issues will be tackled by other papers in this session.

[7]The Auditor general does not provide a counterfactual - i.e., does not estimate the likely change in GA payments in the absence of the FiT - so this is not interpretable directly as the effect of the FiT on the GA. However, this estimate is consistent with those given above, since renewable energy has an offsetting impact on the hourly electric price, so the overall impact is lower than the impact n the GA.

the FiT program.[8,9]

However, even though not all of the electricity cost increase shown in Figure 3 has been due to renewables procurement, the design of the policies to promote renewables in Ontario have increased electricity costs more than necessary to achieve the same outcome. The recent increase in Ontario electricity prices is larger than in nearby jurisdictions, such as New York and Quebec, and also larger than necessary to achieve the reductions in greenhouse gas (and other) emissions that have occurred in Ontario over the past decade (Goulding, 2013).

The FiT and RESOP policies used in Ontario have two attributes that inflate cost: (i) they do not subject firms to competition, but instead provide a fixed tariff, and (ii) they provides much higher tariffs for some types of energy than for others, even though both deliver essentially the same product.

There is significant evidence that a lack of competition allows windfall profits for some program participants, which are borne by ratepayers. Ontario's auditor general, for example, shows that the average costs of the 1570 MW of on-shore wind contracts signed during the competitive procurement programs that existed between 2003 and 2008 was 9.5c/kWh. This is quite comparable to costs estimated by the US National Renewable Energy Laboratory (Moné et al., 2015), for wind installations with a capacity factor of 30%, roughly the experience in Ontario, as shown in Figure 4. In contrast, the non-competitive RESOP program provided 11c/kWh and the FiT program 13.5c/kWh for on-shore wind. The difference in costs between the competitive and non-competitive program likely represents over-payment by the OPA, which inflates overall program costs. These excess costs are illustrated in Figure 4. The Auditor General reports similar overcompensation in the first phase of the FiT program for ground-mounted solar PV installations (Ontario Auditor General, 2011).

2.2 Additional policy objectives need to be carefully scrutinized

The primary differentiator between renewable and other types of electrical generation is that the former is emissions-free, while the latter is often not. Aside from this difference, there is no reason to favour renewable sources of generation over others. However, the *Green Energy and Green Economy Act* promotes a number of ancillary objectives relating to renewable electricity: it aims to 'create' 50,000 jobs in the renewable industry, to provide Ontario's renewable industry with a first-mover advantage compared to other jurisdictions, and via the feed-in tariff to support particular technologies as opposed to remaining technologically neutral. The Auditor General notes that although these goals were central to the legislation and ensuing regulation, they were not adequately thought through and in particular never subjected to a cost-benefit analysis (Ontario Auditor General, 2011).

In fact, the cost of these additional objectives is likely large. Dachis and Carr (2011) estimates that each job created by the GEGEA costs $179,000. Rivers and Wigle (2011) suggests that the domestic content requirements that were initially implemented as part of the FiT likely increased the costs of renewable electricity in the province. Böhringer et al. (2012) finds that the domestic content requirements imposed costs of $130,000 per gross job created, and that overall the policy caused a reduction, rather than a gain, in employment.

Much of the cost of the FiT policy is due to additional objectives. Rather than procure the cheapest forms of renewables, the FiT aims to support a multitude of renewable technologies, including relatively high-cost solar. Incentives to solar are responsible for a large portion of overall costs of the FiT, despite the marginal contribution of solar to the power system. By procuring renewable power at lowest cost, rather than promoting particular technologies, a significant portion of the costs of the FiT could have been avoided.[10] Likewise, in an effort to promote domestic manufacturing of renewable energy equipment, the

[8] McKitrick and Adams (2014) focus only on the global adjustment, neglecting the hourly ontario electricity price. Because renewable electricity provides zero-marginal cost electricity, it has had a negative effect on the HOEP. Taking into account movements in the HOEP would lead to a conclusion that the FiT had a smaller impact on electricity prices than concluded by McKitrick and Adams (2014).

[9] None of these studies considers the environmental *benefits* of the program, so these are gross rather than net costs.

[10] The Auditor General reports that wind energy contracts procured in a competitive bidding process prior to 2006 averaged $95/MWh, which is very competitive with natural gas contracts (Ontario Auditor General, 2011).

FiT program was initially designed with a domestic content requirement. Böhringer et al. (2012) shows that this requirement increased the cost of the program, without promoting overall employment in the province.

2.3 Future policy should be sensitive to the declining value of renewable energy

Electricity generated from solar and wind has two unique features. First, the marginal cost of electricity generated from these sources is essentially zero. That is, once a wind turbine or solar panel is installed, each additional unit of generation imposes no additional costs. Because the marginal cost of renewable electricity is zero, it typically is the first plant dispatached to meet demand in any given hour (plants are normally dispatched according to marginal costs).[11] This shifts the supply curve to the right, and results in a reduction in the hourly price of electricity. This effect can be seen in a crude way on an annual basis in Figure 3, where the decline in the hourly electricity price coincides with the increase in renewable generating capacity. Second, it is intermittent - electricity is generated when the wind blows and the sun shines, but not otherwise. Because the wind blows and the sun shines with some regularity (e.g., the sun does not shine at night; the wind is weakest in summer) this reduction in hourly electricity prices is coincident with peaks in renewable supply. This can be seen in Figure 5, which shows the pattern of relative hourly prices since 2007. Whereas in 2007, peak prices occurred in mid-morning, peak prices today occur at about 8 pm. This is a result of the contribution of solar energy, which produces the largest amount of power around mid-day, and much less in the evening. The addition of solar power has significantly reduced the net daytime demand for energy, but left nighttime demand unaffected. New solar power added today is therefore displacing electricity that is relative lower cost than in 2007. As the cost of energy is a reflection of the value of energy, the value to Ontario of new solar power generation is therefore lower than in 2007. As penetration of solar increases, the value will continue to decline. A similar phenomenon, although less perceptible occurs for wind generation.

Figure 6 shows the changing value of wind electricity in Ontario, with calculations based on the data from the IESO and the method of Hirth (2013).[12] In 2007, when generation from wind was a small portion of total generation, electricity was generated from wind during periods when the HOEP was roughly the same as the annual average HOEP. However, by 2011, electricity from wind had already reduced the HOEP during periods when wind electricity was generated, such that the value of wind was only about 90 percent of the average. Hirth (2013) shows that as wind (or solar) increases to a more significant portion of the total electricity capacity, the value continues to decline. For example, when wind is 30% of total capacity, it's value share can decline to 0.5.

The design of the FiT program is not sensitive to the change in the value of power generated. As renewable electricity capacity expands, it is important to consider it's marginal value, and to prioritize resources with the highest value. For example, under a competitive procurement process, additional value can be given to generation that occurs at peak compared to off-peak periods, and a FiT-type program could be structured as a subsidy relative to the hourly price rather than a fixed tariff.

3 Conclusion

Through a series of policies, Ontario has dramatically changed its electricity generating portfolio over the last decade, especially by eliminating coal-fired generation and rapidly integrating new renewable generators. While the policies used have been successful in transforming the electricity sector, they have done so at higher cost than necessary, especially as a result of ancillary objectives embedded in procurement policies, a lack of competition in procurement, and a lack of sensitivity towards the intermittent nature of renewables. Future policy should aim to address these weaknesses.

[11] This dispatch order is also a feature of Ontario's FiT, which allows renewable electricity generators to bypass the normal dispatch calculations performed by the system operator.

[12] Similar calculations are not possible for solar electricity in Ontario, as the generation data is not available from the IESO.

Figures

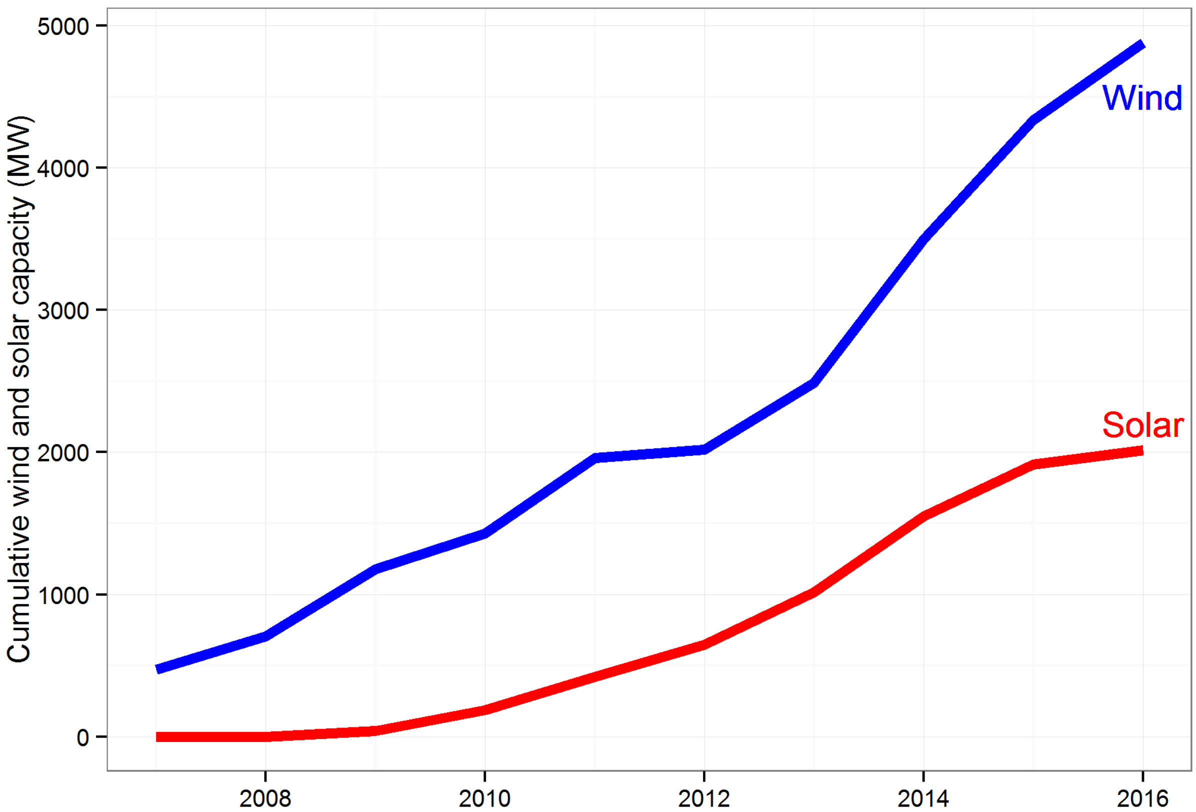

Figure 1: Wind and solar capacity in commercial operation in Ontario. Data from IESO Quarterly Progress on Electricity Supply. Data for 2015 and 2016 is a forecast based on IESO estimates for in-service operation dates.

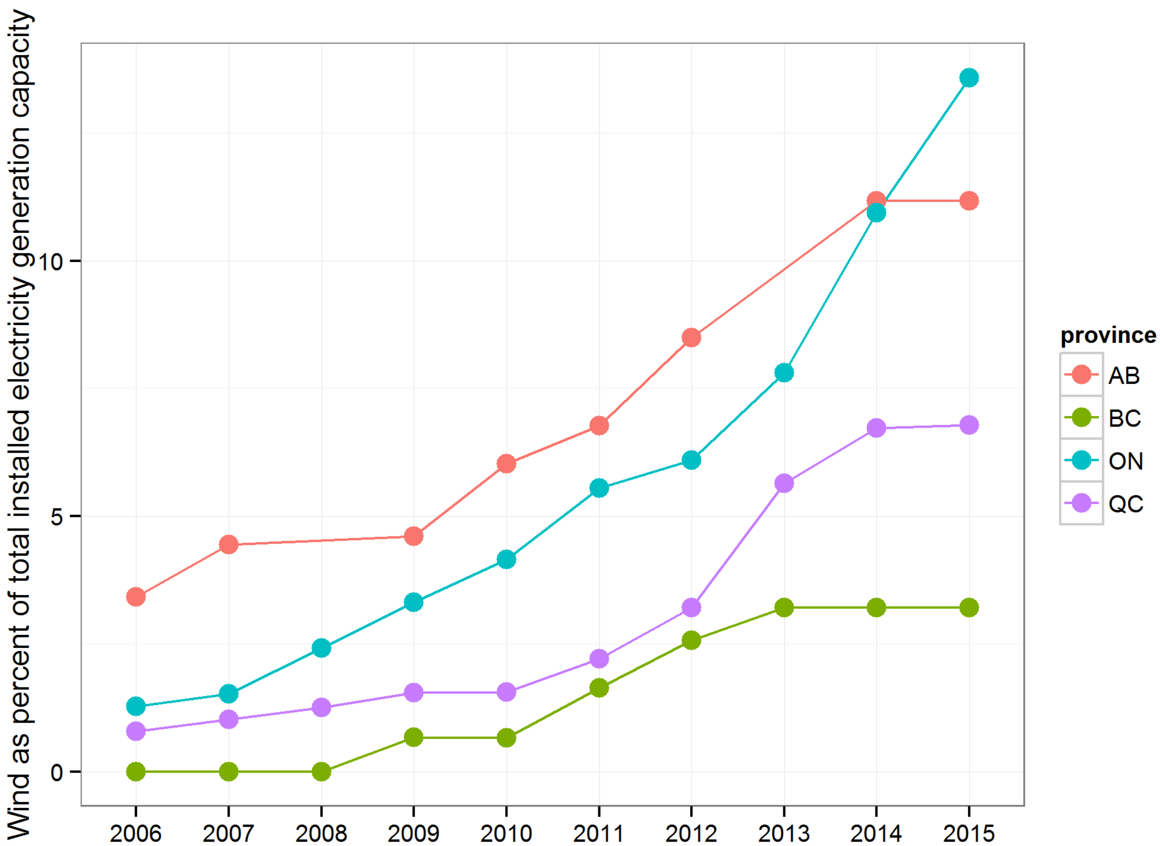

Figure 2: Wind energy capacity in selected provinces as a proportion of total generating capacity. Wind energy capacity from CANWEA's database of installed wind power. Total generating capacity from CANSIM 0127-0009.

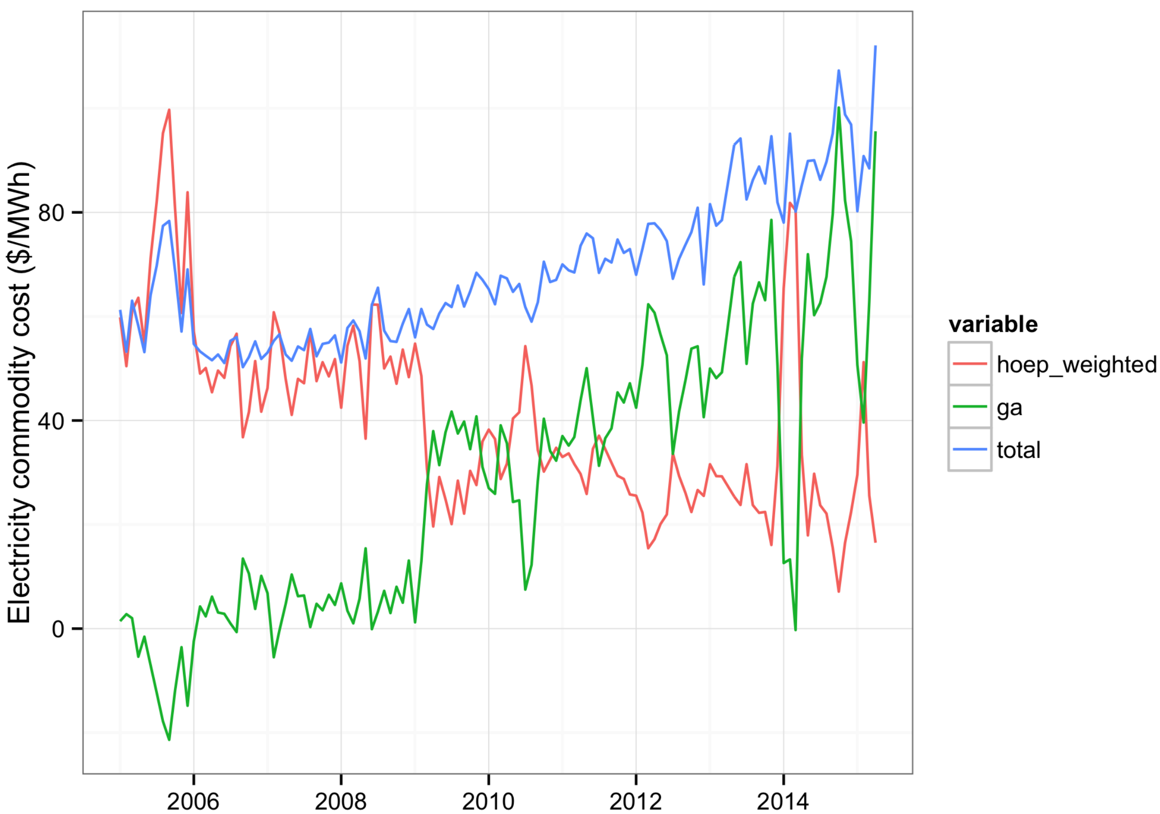

Figure 3: Ontario electricity commodity prices. Data from IESO.

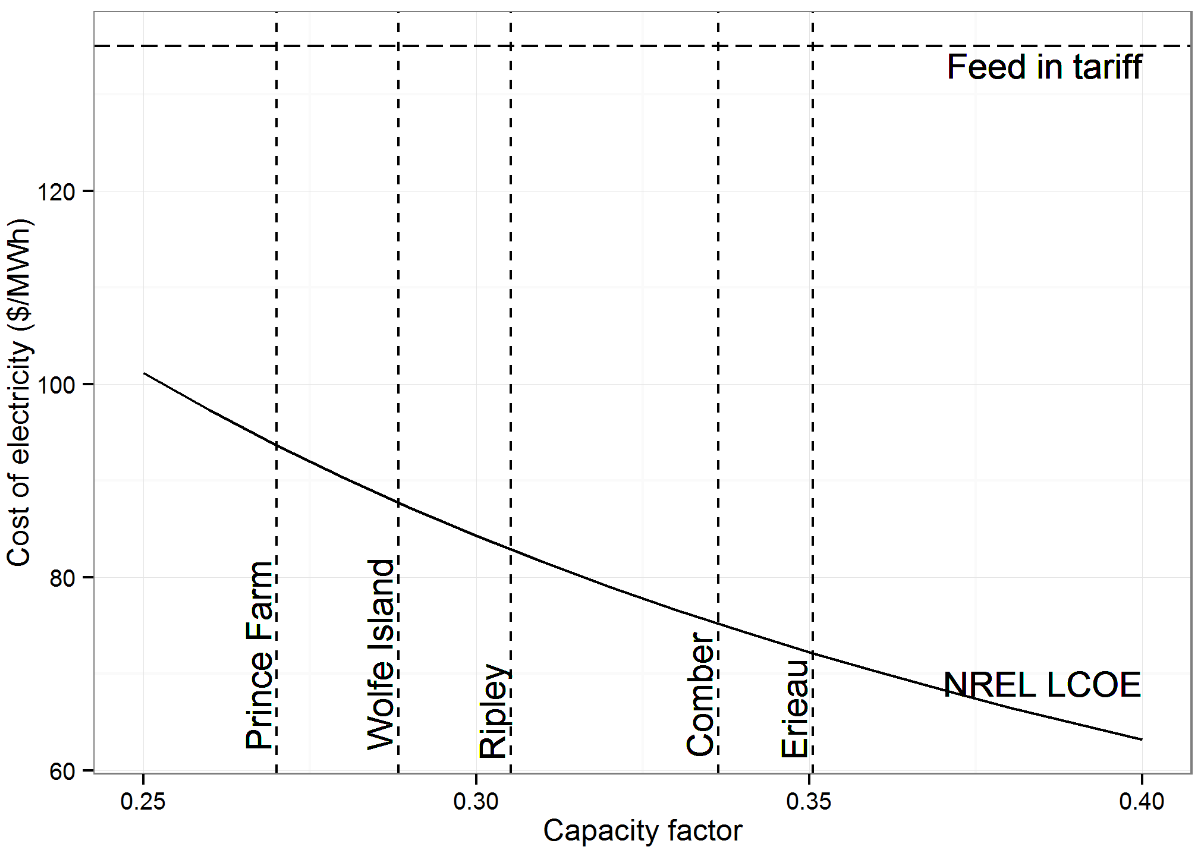

Figure 4: Capacity factor and costs of generation. Capacity factors of Ontario wind farms calculated by author based on IESO data. Cost of generation based on NREL model.

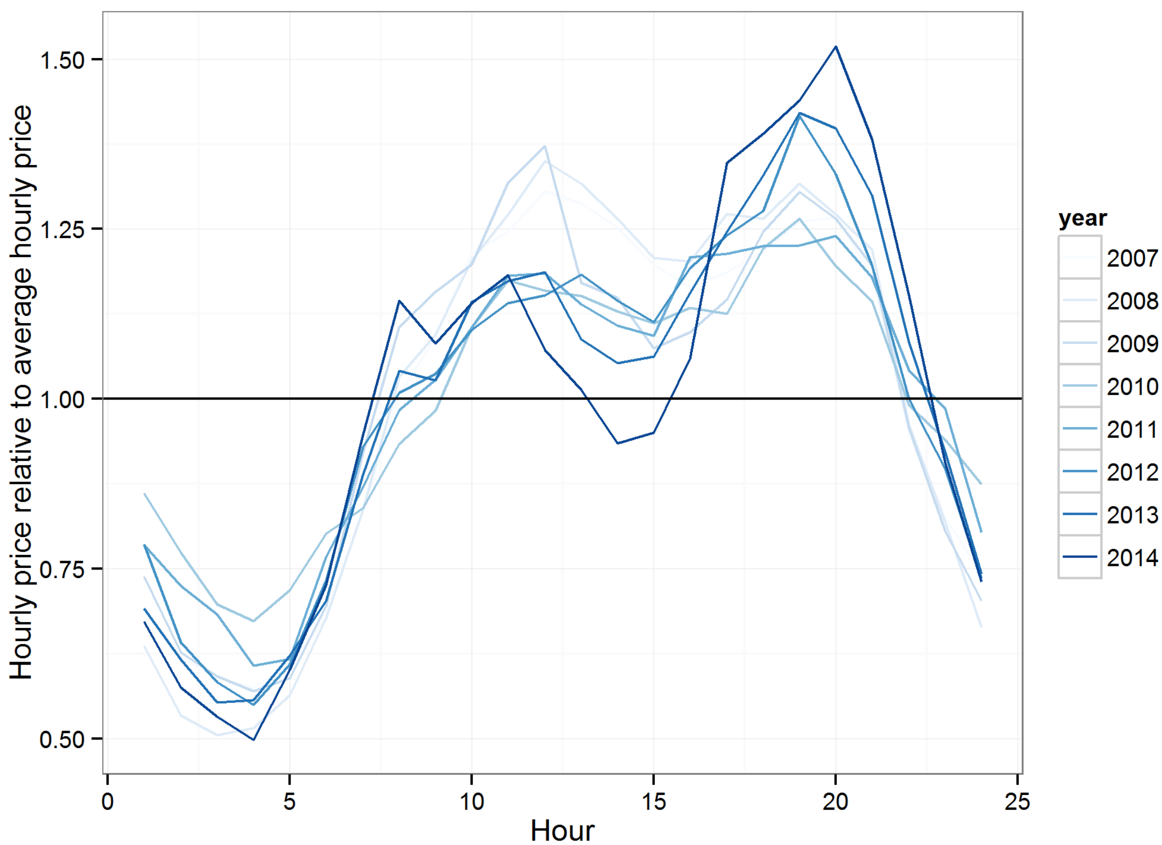

Figure 5: Hourly price of electricity (HOEP) by year as a fraction of average annual hourly price. Data from IESO. Calculations by author.

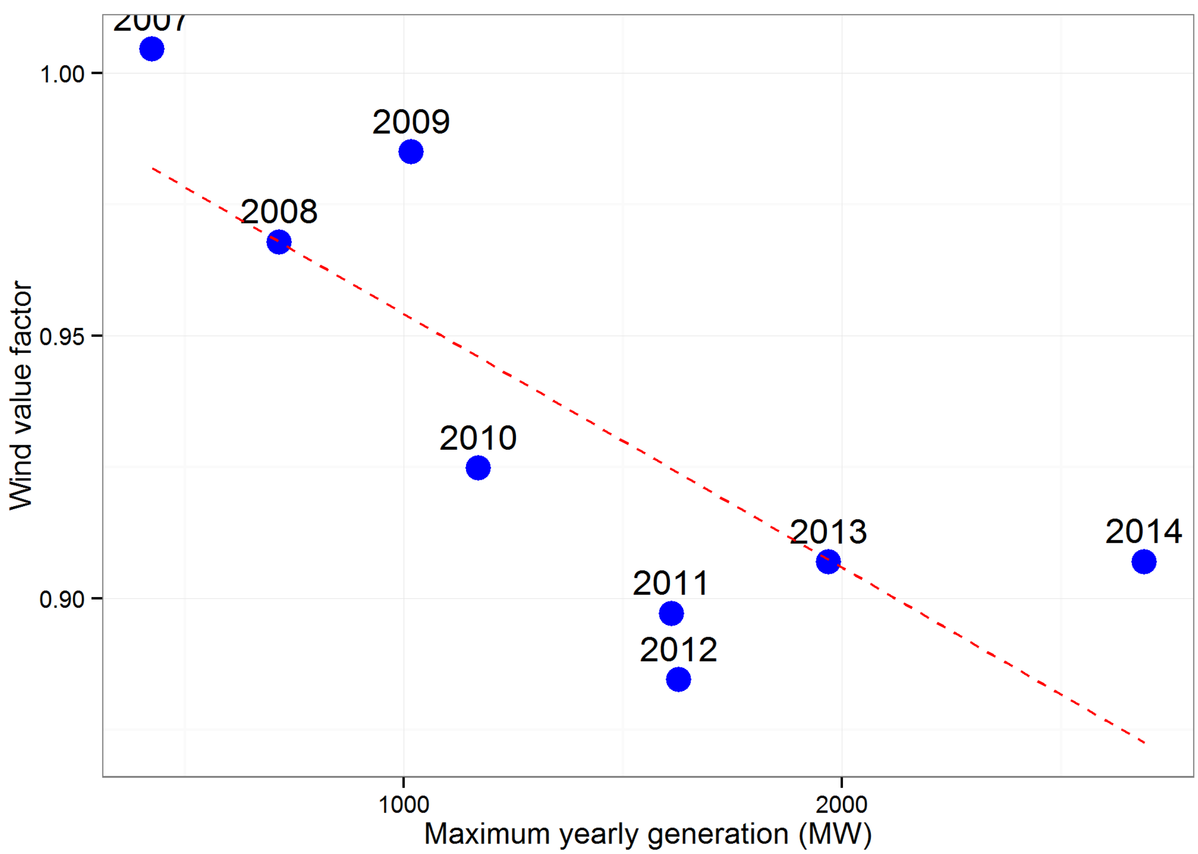

Figure 6: Wind value factor. Data from IESO. Calculations by author.

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