

NFAT Review:
Green Action Centre Evidence on Wind

Presentation to the
Public Utilities Board of Manitoba

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Power Advisory's mandate is "to review and analyze wind energy being integrated as an alternative energy source for Manitoba Hydro"

- Working on behalf of the Green Action Centre
- Major findings:
  - Manitoba Hydro's application significantly over-estimated the cost of wind generation
  - The potential for wind generation was not adequately explored in the fifteen development plans considered in MH's application

Manitoba Hydro has significantly over-estimated the cost of wind generation

- MH's assumptions:
  - Overnight capital costs $2100/kW excluding transmission costs
  - Bulk of costs spent two years before COD
  - No decline in real costs over time
  - Project life 20 years
  - Wind integration cost: $8.45/MWh
- These assumptions are taken from a spreadsheet ("lca_308_attachement_1.xlsx") provided by MH in response to Information Request LCA/MH I-308. The spreadsheet contains calculations of the Levelized Cost of Energy (LCOE) for various projects and technologies, and is referred to hereinafter as "the LCOE spreadsheet".
  - MH's application itself used different numbers, in particular for capital costs and O&M costs, and is missing information on some assumptions
  - MH has confirmed that the numbers in the LCOE spreadsheet are generally consistent with those used in the economic analysis.

Actual wind costs in 2012 in the U.S. were 10% lower than MH's assumption

- MH's assumptions: $2100/kW, excluding transmission costs, in 2012 $.
  - Supported by two engineering estimates, one very out of date, taken from studies of multiple technologies ranging from coal to solar.
- The U.S. Department of Energy's *2012 Wind Technologies Market Report* includes actual costs for 72% of wind capacity completed in the U.S. in 2012. The average cost of these projects was $1,940/kW (p. 34).
- This includes transmission substation and/or interconnection expenses, so an adjustment is needed to make it comparable to MH's number. $1,890/kW should be used for the wind plant costs excluding transmission.

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Manitoba Hydro's construction schedule is too pessimistic

- MH's assumption:
  - 3% of overnight capital costs are spent three years (i.e., 36 to 25 months) prior to COD: monitoring, permitting, etc.
  - 97% spent two years (24-13 months) prior to COD: wind turbines, civil and electrical work, commissioning
  - 2% spend in the year prior to COD: commissioning
- Power Advisory asked three developers about their construction cost forecasts.
  - 3 years (36-25 months) before: 5% for testing, permitting, etc.
  - 2 years (24-13 months) before: 35% turbine deposits
  - 1 year (12-1 months) before: remainder of turbine costs plus on-site work

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There is strong evidence to support a 25-year project life for wind

- MH "maintains use of 20 years is a reasonable estimate consistent with asset life used by others in the industry such as BC Hydro, NREL, Irena and Vestas" (Rebuttal Evidence, p. 61).
  - Most of these sources simply use 20 years, without actually providing evidence
- What is the evidence?
  - Manitoba's wind farms have contracts with terms of 25 years (St. Leon) and 27 years (St. Joseph)
  - Of the five reports cited by MH in support of a 20-year project life, actually says that based on research, wind turbine useful life is estimated to be 20–30 years (Jiminez, p. 48)
  - Some newer Vestas turbines come with 25-year warranties.
  - Power Advisory asked developers what they, and investors, use in evaluating wind projects. Their answer: 25 years.

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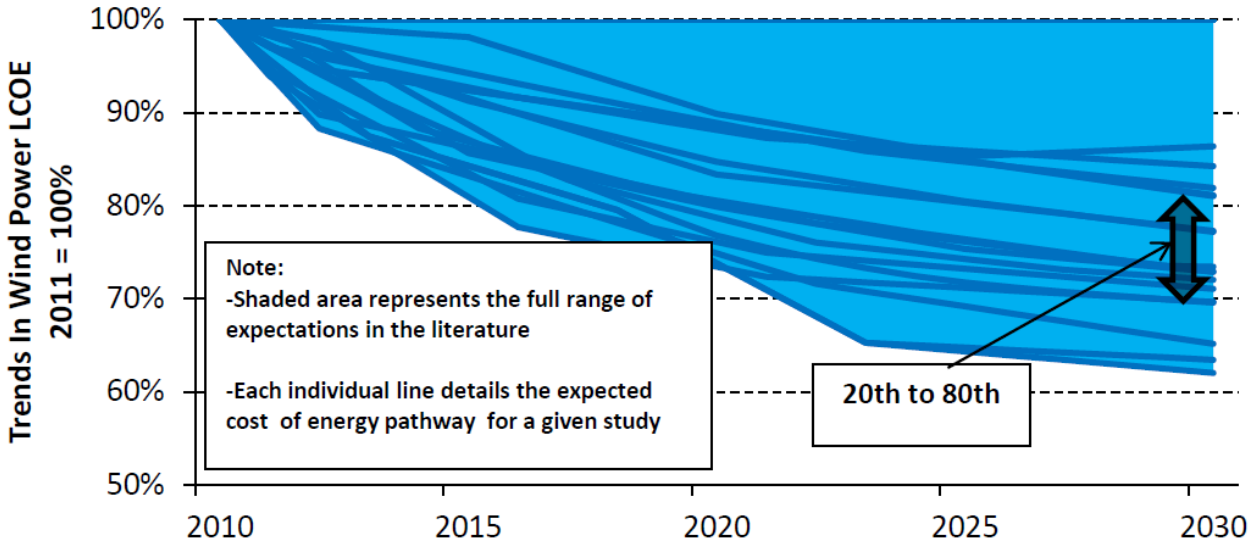
There is a strong consensus among experts that wind costs will decrease substantially over time

Estimated Range of Wind LCOE Projections Across 18 Scenarios



Source: NREL, *The Past and Future Cost of Wind*, IEA Task 26, May 2012, Figure 11, p. 26.

- MH's assumption of no cost decrease is an outlier among expert opinions
- The mid-point of expert opinions is a decline of around 25% by 2030
- While the expected $/MWh cost reduction is due to both lower capital costs and higher capacity factors, it is simpler to model it as a 25% decrease in capital costs holding capacity factors steady
- This should affect both initial capital costs and replacement costs after 25 years

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MH's wind integration cost assumption is unsupported

- MH's application gave a cost of $4.22-4.99/MWh, based on a 2005 study, which tied it to the electricity export price, but the LCOE spreadsheet doubles this to $8.45/MWh
- MH has provided almost no information on how wind integration cost doubled while electricity costs have fallen
- However, MH has stated that "today Manitoba Hydro's wind integration experience is generally consistent with the 2005 study results." (respond to IR GAC/MH I-013).
- Ideally, MH would have provided information on actual costs. In the absence of information on how the higher number was derived, the assumptions and analysis behind it, and whether these are reasonable, Power Advisory suggests using $4.22/MWh in 2012 dollars, as a conservative basis for screening wind generation and the only evidence-based number available

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Using evidence-based assumptions, wind generation is less expensive in LCOE terms than either Keeyask or Conawapa

Technology	LCOE	Source
On-shore Wind (MH Original)	$84.07	LCOE spreadsheet, tab 22 (MH response to IR LCA/MH I-308)
On-shore Wind (PA)	$64.88	Power Advisory
Keeyask (updated)	$68.26	MH Undertaking #41 (Exhibit #114)
Conawapa (updated)	$72.29	MH Undertaking #41 (Exhibit #114)

- LCOEs are in 2014 $/MWh, including transmission, at load
- Power Advisory's wind LCOE calculations are the same as those in MH's LCOE spreadsheet, with the following assumptions changed:
  - Plant capital cost excluding transmission: $1,890/kW in 2012 $, minus 8% for cost reductions between 2012 and 2022
  - 3-year construction schedule with spending split 5%/35%/60%
  - 25-year project life, with replacement based on then-current capital costs; transmission station and lines replaced after 35 and 50 years respectively; 68-year study period after COD to match Keeyask and Conawapa.
  - Wind integration cost $4.22/MWh in 2012 $.

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MH's Development Plans did not adequately consider wind generation

- Only two plans included wind generation: Wind/Gas and Wind/C26
  - As La Capra noted, the Wind/Gas Plan was not optimized: "rather than abandon wind as a resource option, it would have been reasonable for MH to evaluate alternative plans with different sequencing and timing of the wind and gas generation, plans with alternative capacity resources (such as CCGTs or demand response measures), and plans that varied the amounts of wind developed" (Technical Appendix 3B: Alternative Resource Plans, p. 3B-29)
- No plans were considered that combined wind with new transmission interties and new export contracts

Could wind be paired with hydro to increase Manitoba's export potential?

- Wind generation does not necessarily occur when it is most needed, but this could be an advantage, not a disadvantage
- In Manitoba, it may be possible to reduce hydro generation when wind generation is high, leaving more water in reservoirs or lakes, and use that water at other times to increase hydro generation when export demand is highest
  - More than just "firming", wind and hydro should be considered as an integrated system
  - This could work either with existing generation or with new hydro generation
  - While wind plants in mid-western states may have slightly better wind regimes and be closer to loads, they do not have the benefit of potential integration with hydro on the same scale as Manitoba
- MH was asked about this (IR PUB/MH I-026a), but declined to consider it, choosing instead to look at wind on a stand-alone basis in direct competition with U.S. wind.

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Could wind be used to adjust for the inevitable errors in demand forecasts?

- Wind can be developed on fairly short notice – approximately two years from significant commitment of capital (for deposits on turbines) to commercial operation
  - For comparison, Keeyask will take six years from significant expenditure to COD, and Conawapa will take twelve
  - There would be a small cost for developing wind sites short of ordering turbines, and holding them in reserve
- Paul Chernick indicates that, with adequate conservation measures, Manitoba's electricity demand could be kept flat
- Even if this turned out to be optimistic, there is no need to commit to major hydro projects at this time. If demand is higher than expected (whether because of high economic growth, or less effective conservation measures, or any other reason), the difference can be made up on short notice with wind.
- Wind supplies far more energy than capacity, but gas generation – in particular, combustion turbines– can be developed on equally short notice

Wind should be considered more seriously in any long-term plan Manitoba's electricity system

- Wind is the lowest-cost type of generation available in Manitoba, less expensive on a LCOE basis than Keeyask, Conawapa, gas-fired CCGTs, or any other of the technologies considered in MH's application (based on LCOEs for non-wind generation shown in Appendix 7.2, Table 7.2-1, p. 8, compared to Power Advisory's revised wind LCOE calculation above). As such, it should be considered in a wide range of development plants, with timing of wind and other types of generation fully optimized.
- It may be possible to pair wind with either existing or new hydro to serve export markets. This has not been adequately studied.
- Wind projects could be prepared (but not completed) and held in reserve in case demand increases unexpectedly, as a form of risk-management.