Offshore wind power via Lake Erie

Response to Red flags on green energy published in The Globe and Mail on Wednesday, Feb. 16, 2011

Matthew McCarville

Thursday, Feb. 17, 2011

The surface of Lake Erie is 25,745 km^2 [1]. The Canada Wind Energy Atlas shows the lake has a mean wind speed of 7-9 m/s at 80 m hub heights [2]. Modern offshore wind turbines can reach hub heights up to 100 m. Wind speeds greater than 7 m/s correspond to wind power capacity factors of 30% or more of nameplate capacity so the whole lake is relatively economical to develop.

A bathymetry map shows the lake is mostly 0-20 m deep and relatively flat, so simpler structures can be constructed compared to deeper waters [3]. Estimating offshore wind resources is fundamentally different than estimating onshore wind or mineral resources. It involves understanding exclusions and limitations on turbine placement, e.g., wind tower technology limits on water depth, competing human uses of lake space, and wildlife or ecological vulnerabilities. Kempton, Archer, Dhanju, Garvine and Jacobson (2006) use an exclusion fraction of 0.46 to assess large CO_2 reductions via offshore wind power matched to inherent storage in energy end-uses in northeastern United States [4]. Thus, exclude half (12,873 km^2) of Lake Erie for reasons of water depth, competing human uses of lake space, and wildlife or ecological vulnerabilities as a start.

Blade diameter for the 5 megawatt (MW) REpower 5M wind turbine is 126 m. To minimize inter-turbine wake losses, spacing of about 0.79 km^2 per 5M is needed [5]. Thus, it is possible to install 16,295 5 MW wind turbines or 81,475 MW total capacity on half of Lake Erie. The average capacity factor of this wind is perhaps 36%. Maintenance typically occurs during low wind speeds, and less than 2% of the year so it is ignored. To estimate annual power output, 81,475 MW of capacity is multiplied by the factor of 0.36 and by 8,760 hr/yr and so 256 terawatt hours per year (TWh/yr) of wind power could be generated with 5 MW wind turbines on half of Lake Erie. Ontarians use 152 TWh/yr [6].

Jacobson (2008) ranked energy solutions to global warming, air pollution and energy security, and found the lifecycle CO_2 equivalent (CO_2e) emissions of wind is 9-17 times less than nuclear energy. This includes the mining and processing of uranium ore, transportation, enrichment, construction of plants, plus background CO_2e emissions from the current power grid due to planning-to-operation delays of 11-19 years for nuclear power compared to 2-5 years for wind power development. Jacobson and Delucchi (2010) estimate that 3,800,000 5 MW wind turbines, 49,000 300 MW concentrated solar plants, 40,000 300 MW solar PV power plants, 1.7 billion 3 kW rooftop PV systems, 5350 100 MW geothermal power plants, 270 new 1300 MW hydroelectric power plants, 720,000 0.75 MW wave devices, and 490,000 1 MW tidal turbines can power a 2030 world that uses electricity and electrolytic hydrogen for all purposes. Such an infrastructure reduces world power demand by 30% and requires only 0.41% and 0.59% more of the world's land for footprint and spacing, respectively [7].

Of the 256 TWh/yr of wind power available from half Lake Erie, 3 TWh/yr can power one million electric cars [8]. Battery electric vehicles can be plugged into the power grid for 22 hours per day so Lake Erie's wind can be stored automatically using Ontario's smart meters. Ultimately, large CO_2e reductions via offshore wind power matched to inherent storage in energy end-uses such as transportation and heating is doable today with existing technologies. High voltage direct current transmission line losses are 3% per 1000 km and can also connect geographically dispersed wind sites to load centers with more reliability than individual locations. More data and study is useful to help Ontarians conserve, become efficient and use wind and other renewables wisely. Nevertheless, there is still reason to be excited about the abundance of this natural resource and prospects of renewable offshore wind power integration.