IESO – Will Ontario's wind turbine power plants reduce greenhouse gas emissions?

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Coal-fired power plants in Ontario are to be phased out by 2014 and are being replaced by natural gas-fired power plants. Wind turbine power plants are being built in the belief that they will reduce the greenhouse gas (GHG) emissions from the gas-fired plants. Dispatchable coal is being replaced by dispatchable gas and not by non-dispatchable wind.

There is some doubt whether the billions of dollars being spent by Ontario's electricity consumers on Ontario's wind turbine power plants and their supporting transmission infrastructure and on increased maintenance for gas-fired and nuclear generators on the grid, will result in any appreciable, or even any, reduction in GHG emissions from the electricity generating sector. It is difficult to impossible for the layman to get a handle on this due to the highly complex operation of the grid by the Independent Electricity System Operator (IESO). If it were possible to frequently shutdown gas-fired power plants every time the wind picked up there might be some obvious GHG reductions but even then shutting down and then re-starting gas-fired units would eat into the amount of the reduction as well as increasing the amount of wear and tear damage to the units.

Since the only people who know in detail how the generators on the grid are dispatched to accommodate wind are the people doing this job every day at the IESO they are the only ones who can come up with the answer to the question, "are wind turbine plants really reducing GHG emissions in Ontario and at what cost per tonne CO2 avoided?" This really is the bottom line. It should not be too difficult for them to use computer simulation to compare typical daily load profiles with and without wind generation and with various water storage levels and compare emissions as a result of their usual dispatching procedures. While we wait for this to happen (!) let us look at scenarios that raise doubts about GHG reductions.

Ontario's grid consists of many and varied generating stations located throughout the province feeding consumers through a network of high voltage transmission lines, transformers, switchgear, and low voltage distribution lines to major consumers including local utilities. Electricity cannot be stored in large amounts so generation and demand has to be kept in balance at all times. If demand exceeds supply all the generators on the grid slow down and the normal grid frequency of 60 Hertz (reversals per second of alternating current) will drop. All electric motors working off the grid would similarly slow down. If supply exceeds demand the frequency will increase. It is the job of the IESO to ensure that these frequency swings keep within very tight tolerances on a second to second time scale. It does this by dispatching generators (hydro, coal, gas, and even nuclear units as a last resort) on the grid at five minute intervals, not necessarily the same generator, to move power up or down. In the morning the power moves would generally be in an upward direction and in the evening in a downward direction but there can also be small reversals in the general trend. This brings the grid into a rough balance. In order to bring the frequency into its narrow operating range of around 60 Hertz the IESO automatically controls the output of a very small number of selected generators that have the capability to continuously and rapidly vary their output. These are some hydro units at Niagara Falls and , in the past, some coal-fired units. As well as frequency, voltage levels at points on the grid also have to be maintained but this is more complex and will not be discussed.

The hydro generators consist of run-of-the-river stations, like Niagara Falls, that run continuously and stations that depend on water storage, so have limited run times and are more dependent on precipitation. The run-of-the-river units would provide base load and the stored water units would provide intermediate load that looks after the normal daytime load cycle. The hydro stations are extremely flexible when available and can quickly respond to changes in supply or demand on the grid. However there can be water management restrictions on the operation of the stored water units because of variations in upstream and downstream water levels and other concerns. Coal-fired units are less flexible but more flexible than the combined cycle gas turbine units that are replacing them and both can provide base load and intermediate load. There are also simple cycle gas turbine units, much less efficient than combined cycle gas turbines, that can come on line very quickly to meet peak loads or other eventualities. Present nuclear units are the least flexible and prefer to operate base load although they are regarded as dispatchable by the IESO. Wind generation depends on the wind and is not dispatchable. In 2009 nuclear provided 55.2 percent of Ontario’s electricity, hydro 25.5 percent, gas 10.3 percent, coal 6.6 percent and wind 1.6 percent. Other fuel types (biomass, solar etc) gave 0.8 percent. This shows 80 percent of Ontario’s electricity was supplied by non-GHG emitting nuclear and hydro putting Ontario’s electricity sector amongst the world leaders in the generation of “clean” electricity. Wind generation is expected to increase drastically over the next few years under Ontario’s Green Energy Act.

In the future large amounts of wind (eventually maybe up to 8,000 megawatts nameplate capacity when transmission links are completed) will have an impact on the grid in both high electricity demand and low demand scenarios. Wind is a preferred supplier under present government rules and must be accepted on to the grid when available. During daily operation when the demand on the grid is high and wind starts coming on to the grid other units on the grid will have to power down to maintain grid balance. The other units could be hydro or gas. If hydro is powered back it would help conserve water behind the dams but would not reduce GHG and other emissions from the gas units. If the combined cycle gas turbines are powered down there still might not be any significant GHG reductions since the units cannot be completely shutdown. Some will be held in their load dispatching range of around 70 to 100 percent of full power to be available for dispatching and some would fall below their load dispatching range, on hot standby, in case the wind dropped. A sudden drop in wind would bring on the peaker simple cycle gas turbines, and hydro if available, until the combined cycle gas turbines on standby can power up enough to respond to dispatches. Any time gas turbine units operate at part load to accommodate wind the emissions per megawatt hour of generation will increase and there will be wear and tear damage dependent on the depth and frequency of the power changes leading to higher maintenance costs. Also high demand usually coincides with high ambient air temperatures that would reduce output and efficiency of gas turbine units. Output from the stored water hydro units can be restricted during the summer due to drought and, in the future, climate change leading to more gas-fired generation.

The more difficult scenario is the case of oversupply, which tends to occur in the spring and fall, overnight and on weekends. This is called Surplus Baseload Generation (SBG) when the demand is less than a base load supply that cannot readily be reduced because of technical or contractual reasons. There were many cases of SBG in the spring of 2009 caused by the economic downturn and a surplus of hydro power and even with the relatively small amount of wind generation on the grid at that time. SBG is expected to increase in the future, not helped by unscheduled wind, until an improving economy and growing population increases demand. As the wind generation comes on to a grid that already has low demand the gas units are powered down, base load hydro minimized and, if possible, exports are maximized but enough flexible hydro and gas must be available to handle grid load changes and be available in case the wind drops. Eventually if the wind generation keeps on increasing the present approach is for selected nuclear units to make one significant power reduction to another constant power level or shutdown completely, and be replaced by more gas, and hydro if available. When a nuclear unit is shutdown it will not be available again for up to three days because of nuclear physics reasons so if demand increases over this period it would have to be met with gas-fired generation. Shutting down or powering down nuclear units that produce relatively low cost reliable electricity without GHG emissions and replacing this electricity with higher cost energy from gas and wind makes little economic, technical or environmental sense. Shutting down and restarting nuclear units like this results in wear and tear and increased maintenance cost and puts the grid at risk.

For the wind turbine power plants under the Feed-In-Tariff program (but not those under the earlier Renewable Energy Standard Offer Program) the IESO is offering financial incentives to the wind operators to shutdown their plants during times of SBG. However even if wind is shutdown, if the SBG is deep enough nuclear plants would still need to be shutdown, or powered down, with GHG emitting gas-fired plants taking care of load following on the grid. Under this incentive wind operators would get paid if they shutdown in response to an IESO directive to do so. As more controversial shale gas gets into the natural gas supply it raises the question of life cycle GHG emissions. Even though a gas-fired generator produces just over half the carbon dioxide of a similar sized coal-fired generator, taken on a life cycle basis GHG emissions from burning shale gas may approach or equal coal. In this case it would have made economic sense to keep operating the coal-fired stations with low sulphur coal and flue gas clean-up until new nuclear became available and skip this monstrously expensive and risky venture with gas and wind. Coal has a dispatchable range of 20 to 100 percent full power compared to 70 to 100 percent for gas, which means more non-GHG emitting nuclear would be shutdown (with consequent wear and tear costs) or powered down to avoid SBG by using gas than by using coal and would lead to an increase in carbon dioxide emissions even though carbon dioxide emissions from a combined cycle gas turbine plant are just over half the amount from a coal-fired plant for the same output. For gas to provide the same dispatchable power as coal, with both operating at their respective minimum loading points, several times as much gas generation would have to be on line meaning very much more GHG emissions.

The only sure way to reduce GHG emissions to zero is to have an Ontario grid powered by just hydro and new nuclear plants that will be more flexible than the present ones. It has to be this way eventually. France has been producing 80 percent of its electricity from its flexible nuclear fleet for many years with the balance from hydro and fossil fuels. There need not be any shortage of electricity, anywhere. It can be produced in abundance by nuclear energy at reasonable cost and can meet our needs for thousands of years.

Now the people at the IESO can see why we are all confused about this gas and wind thing! Is Ontario making a huge mistake?

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