$$ Gone with the Wind & Solar

Examining the relative costs of Renewables vs Dispatchable Power in Ontario

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Are Wind and Solar Energy Cheaper Than the Alternatives in Ontario?

EXECUTIVE SUMMARY

Advocates of renewable energy in Ontario say that these energy sources are so low in cost as to be the ideal sources of electricity generation in future. Indeed, they claim wind and solar energy are so inexpensive that electrical utilities should abandon the use of hydrocarbon-based (coal and natural gas-fired) electricity generation. Are they right?

New electricity generation plants entail many different costs. These include the (capital) costs of building the plant, operating and maintaining it, transporting the electricity to markets, and distributing it to the final industrial, commercial and residential consumers. Most consumers care less about the individual cost components than they do about the final prices, or rates, they pay for the electric energy delivered to their homes on a kilowatt-hour basis.

Wind and solar plants increase electricity costs in five ways. They operate at low capacity factors compared to traditional generators. They have a lower life expectancy than conventional power plants, so they depreciate faster. They incur higher transmission costs as they are usually located at long distances from the cities where the electricity is consumed.

They lower the utilization of traditional generating plants. Perhaps most important , wind and solar plants increase system costs because they are intermittent, meaning that they only produce electricity when the wind blows or the sun shines, not when consumers need it. When renewables fail to produce when needed, utilities need a backup system or a system of storage, which is extremely expensive.

In every country and region that has increased the share of wind and solar energy in its system, the electricity rates to consumers have risen considerably.

Successive Ontario governments have followed electricity policies that have made matters worse. Notably, they have consistently over-estimated electricity demand and over-built power generation capacity. This has magnified the number of times when wind and solar power was produced when it was not needed to meet Ontario demand. The result was the increasing number and cost both of curtailment payments to contracted generators and exports of power at heavily discounted prices to neighbouring U.S. States.

The Kathleen Wynne and Doug Ford governments introduced a series of taxpayer-funded subsidy programs to hide from ratepayers the true costs of Ontario electricity policies. Those subsidies are not usually counted and recorded as renewables costs, but they are costs to society nonetheless.

IESO has already provided the Ontario government two reports that should have indicated very clearly the problems associated with pursuit of the “net-zero emissions” or “decarbonization” objective. The main conclusion was that the bulk system expansion needed to enable decarbonization, including transmission, could require an investment in the range of $375 billion to $425 billion.

The continued pursuit of present policy will not only raise prices to unheard of levels but it will lead to a future of rationing, oppressive regulations and economic decline.

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Are Wind and Solar Energy Cheaper Than the Alternatives In Ontario?

Advocates of renewable energy in Ontario say that these energy sources are so low in cost as to be the ideal sources of electricity generation in future. Indeed, they claim wind and solar energy[1] are so inexpensive that electrical utilities should abandon the use of hydrocarbon-based (coal and natural gas-fired) electricity generation. Are they right?

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New electricity generation plants entail many different costs. These include the (capital) costs of building the plant, operating and maintaining it, transporting the electricity to markets, and distributing it to the final industrial, commercial and residential consumers. Most consumers care less about the individual cost components than they do about the final prices, or rates, they pay for the electric energy delivered to their homes on a kilowatt-hour basis.

Decarbonization advocates usually quote the so-called Levelized Costs of Electricity (LCOE) figures published by authorities like the US Department of Energy. The LCOE is calculated as the present value of the total costs of construction and operating over an assumed lifetime of the generating plant divided by the total amount of electricity generated. The LCOE estimates, however, barely begin to cover the costs of wind and solar energy systems.

Explaining Why Wind and Solar Costs are High

Wind and solar plants increase electricity costs in five ways.

First, they operate at low capacity factors compared to traditional generators. According to *Our World in Data*, the current average of all of the world's wind and solar installations in the most recent year for which we have data, 2019, was 14% of nameplate capacity in the case of solar power. In the case of onshore industrial wind turbines, the capacity utilization was only 26%. By comparison, the average capacity factor of modern coal-fired power plants is 42%, that of combined cycle natural gas turbine plants is 57%, and that that of nuclear power plants

[1] Wind power as described in this article concerns the electricity generated by industrial wind turbines. Solar power refers to the electricity produced by solar parks or fields, large areas of land containing interconnected solar panels positioned together and designed for energy generation that feeds directly into electricity grids. This is different from the solar photovoltaic panels often placed of rooftops for site-specific use or for local distribution.

92.5%. This means that to get the same kilowatt-hour production from solar energy you need five times as much capacity as a nuclear plant.

Second, the life expectancy of solar panels and wind turbines is about 25 years. That of a natural gas-fired generating plant is between 30 and 40 years; that of a coal-fired power plant is between 40 and 50 years and that of a nuclear plant is at least 50 years. Solar and wind plants thus are depreciated faster than gas and coal plants and twice as fast as nuclear plants.

Third, they incur higher transmission costs. Solar and wind facilities are spread out, and wind turbines are usually located at long distances from the cities where the electricity is consumed; thus, they require much more land and longer transmission lines.

Fourth, they lower the utilization of traditional generating plants. Whether as a result of regulatory or policy mandates, wind and solar plants are often given priority ("first to the grid rights") in the power hierarchy, meaning that the systems operator must require production from hydro, coal or gas based generating plants to be cut back ("curtailed") on windy or sunny says. Forcing the traditional plants to operate at capacity rates far below what they were designed for makes it more difficult for coal and gas plants to produce enough revenue to cover the original costs of plant construction, requiring electricity prices to be raised to cover the system costs.

Fifth and perhaps most important , wind and solar plants increase system costs because they are intermittent, meaning that they only produce electricity when the wind blows or the sun shines, not when consumers need it. When renewables fail to produce when needed, utilities need a backup system or a system of storage, which is extremely expensive. Without backup or storage, intermittent production could often result in brownouts or blackouts. Yet, the costs of the backup or storage systems are rarely attributed to the use of wind and solar energy.

In every country and region that has increased the share of wind and solar energy in its system, the electricity rates to consumers have risen considerably. In Europe, electricity rates are two to three times as high as in North America. The higher the percentage of wind and solar energy used, the higher the rates. A 2016 study by Stephen Brick and Samuel Thernstrom analyzed electricity systems in California, Wisconsin and Germany. It projected that, in the case of California, overall system capacity would rise by 69 per cent with 50 per cent renewables penetration, and rise by 130 per cent when renewable penetration reached 80 per cent. **With 80 per cent renewables penetration, the wholesale price of electricity would rise by 269 per cent.**

The Situation in Ontario

Successive Ontario governments have followed electricity policies that have made matters worse. Notably, they have consistently over-estimated electricity demand and over-built power generation capacity. This has magnified the number of times when wind and solar power was produced when it was not needed to meet Ontario demand. The result was the increasing number and cost both of curtailment payments to contracted generators and exports of power at heavily discounted prices to neighbouring U.S. States.

A recent report by the McDonald Laurier Institute entitled *Chasing the Wind* described this.

"*From 2009 to 2022, wind generation accounted for $2.0 billion of the $4.5 billion increase in Ontario electricity generation costs, as wind increased its percentage of the generation mix from 1.6 to 10 per cent. That is, wind accounted for 44% of the increase in generation costs and 37% of the overall system costs that were charged to ratepayers.*"

The report notes that the actual cost of wind turbine generation paid for by ratepayers/taxpayers from 2014-2020 was $143/MWh and from 2020-2023 was $151/MWh. That, however, does not reflect its true costs due to the effects of the "first-to-the-grid" rights embedded in their contracts. For example, Ontario Power Generation was required to spill 6.6 terawatt-hours (TWh) of hydro from 2020-2023 and was paid $30/MWh which represents a cost of $198 million. **The 6.6 TWh were presumably generated by the wind turbines; at the $151/MWh received, the cost was 996.6 million.** Considering the modest payments received for the exported electricity, Ontario ratepayers were forced to cover the loss of about $1 billion. Including all of the costs required by wind turbine-induced curtailment, $7.8 billion was added to Ontario ratepayers' costs.

It gets worse. The Kathleen Wynne and Doug Ford governments introduced a series of taxpayer-funded subsidy programs to hide from ratepayers the true costs of Ontario electricity policies. In 2022 the Ontario government subsidized electricity prices to a total of $6.1 billion through a half dozen programs, some of which ear-marked specific generation segments. The largest single subsidy program is the $3.1 billion Renewables Cost Shift (RCS), which is specifically targeted at wind, solar and bio-mass generation. **The wind and solar components of RCS are $1.5 billion each, with the bio-mass component at $0.1 billion. Those subsidies are not usually counted and recorded as renewables costs, but they are costs to society nonetheless.**

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The data published by Ontario's Independent Electricity Systems Operator (IESO) illustrates the financial burden of wind and solar energy at the system-wide level. IESO's most recent report indicates that Ontario's current installed generation capacity is 26,364 MW, of which wind represented 4,943 MW (13%) and solar represented 478 MW (1%). The yearly output in 2023 was 148.74 TWh, of which wind represented 8.2% and solar represented less than 1%. **In other words, despite their outsized impacts on electricity supply costs and their favoured status in terms of grid access, wind and solar combined produced less than 9.2% of total generation.**

There of course are other non-financial costs to society, notably the deaths of hundreds of thousands of birds and bats, the adverse effects of wind turbine noise and infrasound on people, the adverse effects on ground water quality, the "visual pollution" of turbines in formerly pristine rural areas, and the constantly increasing burden of adding retired wind rotator blades to landfill sites.

Future Costs

IESO has already provided the Ontario government two reports that should have indicated very clearly the problems associated with pursuit of the "net-zero emissions" or "decarbonization" objective. In the *Decarbonization and Ontario's Electricity System* report of October 2021 and the *Pathways to Decarbonization* report of December, 2022, IESO set out its professional assessment of the costs and risks associated with decarbonization by 2050. The following are some of the most compelling observations in those reports:

- **Ontario's electricity system today is 94% emissions-free and contributes only three per cent to the province's total greenhouse gas emissions.**
- Natural gas generation plays a crucial role in the reliability of the electricity grid. It provides a range of services that no other resource today can provide on its own, including producing large amounts of power to meet high demand and running for extended periods when other resources are not available.
- **Phasing out natural gas generation by 2030 would entail a capital investment of more than $27 billion and bring the cost of carbon reduction in the electricity industry to at least $464 a tonne (far above any reasonable estimate of the "social cost of carbon")**.
- A "Pathways scenario" to decarbonization projects a system designed to meet winter peaks that are almost three times higher than those we experience today, and thus require an additional 69,000 MW of "non-emitting" supply and 5,000 MW in demand reduction from conservation. ("Conservation" is sometime a euphemism for demand destruction, the process whereby consumers are forced by higher prices to reduce their use.)
- The scenario includes an additional 17,800 MW of nuclear supply, and additional 17,600 MW of wind and 650 MW of new hydroelectric, plus an additional 2,000 MW of long-duration storage added in the late 2030s. It assumes that hydrogen becomes a cost-effective resource for meeting peak demand by 2036 and that new hydrogen capacity of 15,000 MW is available by 2050.
- This would require anywhere from 50 to more than 280 new transformer stations, at costs ranging between $5 billion and $10 billion. This also would require new transformer stations to be built at the rate of up to 10 stations per year, a pace exceeding the addition of new stations over the last decade.
- The cost of building out the bulk 500 kV and 230 kV transmission systems to meet the Pathways scenario is estimated to be between $20 billion and $50 billion. This construction will pose "substantial" siting challenges. (This is the understatement of the century.)
- **The bulk system expansion needed to enable decarbonization, including transmission, in this scenario would require an investment in the range of $375 billion to $425 billion.**

The IESO reports did not include an estimate of the impact on electricity consumers' rates. The Ontario government also has not published the figures.

Flawed Assumptions Behind the Decarbonization Objective

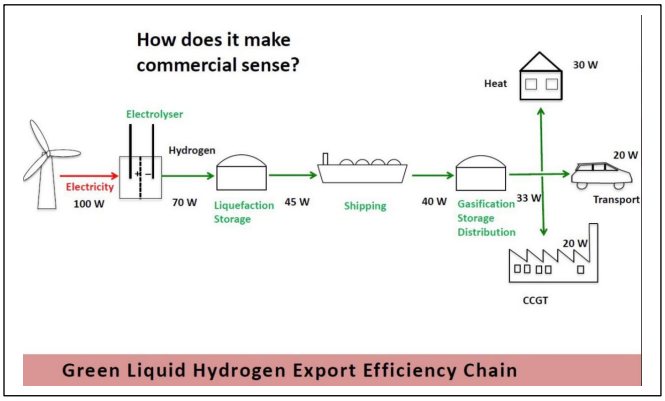
The scenario of complete decarbonization by 2050 in Ontario is riddled with false assumptions about the costs of the measures required, the availability and costs of the technologies and the capacity of governments to centrally plan the economy so as to achieve revolutionary change in a period of 27 years.

As noted previously, wind and solar facilities provide only intermittent power, which must be fully backed up by something – fossil fuel generators, nuclear plants, batteries, or some other form of energy storage – so that customer demand can be matched at times of low wind and sun, thus keeping the grid from failing. The governments pursuing the "Net Zero" objective have mostly or entirely ruled out fossil fuels and nuclear as the backup, leaving some form of storage as the main or only remaining option. They have then simply assumed that storage in some form will become available.

Their consideration of how much storage will be needed, how it will work, and how much it will cost has been entirely inadequate. The Global Warming Policy Foundation recently published an article on this subject by Francis Menton, an American analyst who writes as the "Manhattan Contrarian". In the article, Menton notes that building enough energy storage to back up a predominantly wind/solar generation system is an enormous problem, and very likely an unsolvable one.

"*At this time, there is no proven and costed energy storage solution that can take a wind/solar electricity generation system all the way to Net Zero emissions, or anything close to it. Governments are simply setting forth blindly, without any real idea of how or whether the system they mandate might ultimately work or how much it will cost. The truth is that, barring some sort of miracle, there is no possibility that any suitable storage technology will be feasible, let alone at affordable cost, in any timeframe relevant to the announced plans of the politicians, if ever. This report seeks to shine a light on the critical aspects of the energy storage problem that governments have been willfully ignoring. Section 1 shows that full backup is indispensable in an electricity grid powered mainly by intermittent generation. Without it, there would be frequent blackouts, if not grid collapse.*"

Menton assesses the cost and feasibility of acquiring battery storage on the scale required to deliver Net Zero. Even on the most optimistic assumptions, the cost could be as high as a country's annual GDP, thus rendering the entire Net Zero project an impossibility. On less optimistic assumptions, the capital cost alone could be 15 times annual GDP. Further, it is not just costs that render the goal infeasible, but also practical limitations. Current battery technologies provide about four hours of discharge at maximum capacity, but weather patterns mean that grids need batteries that can store as much as a month's demand, and then discharge that energy over the course of six months or more. Such 'long duration' batteries have not yet been invented.



To cite another example of a technological barrier, consider the prospects for hydrogen. It is highly debateable whether hydrogen power will play a major role in the future energy economy. Despite the investment of many billions of dollars in hydrogen power research, especially in the USA, the fundamental problems with hydrogen as an energy carrier remain. Consider, for example, the problems of transportation and distribution. Before hydrogen can be transported anywhere, it needs to be either liquified or compressed. To liquify it, it must be cooled to a temperature of −253◦C. At this temperature, refrigerators are extremely inefficient; as a result, about

40% of the energy in the hydrogen must be spent to liquify it. In addition, because it is a cryogenic liquid, still more energy would be lost as the hydrogen boils away during transport and storage.

As an alternative to liquifying it, one could use high pressure pumps to compress it. This would only waste about 20% of the energy in the hydrogen. However, safety-approved steel tanks capable of storing hydrogen at 5000 psi weigh approximately 65 times as much as the hydrogen they can contain. Consequently, to transport 200 kilograms of compressed hydrogen, roughly equal in energy content to 200 gallons of gasoline, would require a truck capable of hauling a 13-ton load. In principle, a system of pipelines could, at enormous cost, be built for transporting gaseous hydrogen. But because hydrogen is so diffuse, with less than one third the energy content per unit volume of natural gas, these pipes would have to be very big, and large amounts of energy would be required to move the gas along the line.

Another problem is that hydrogen can penetrate readily through the most minutely flawed seal, and can actually diffuse right through solid steel itself. This would create ample opportunities for much of the hydrogen to leak away during transport. As hydrogen diffuses into metals, it also embrittles them, causing deterioration of pipelines, valves, fittings, and storage tanks throughout the entire distribution system. Unless very carefully monitored, the pipeline system could become a continuous source of catastrophes. Given these technical difficulties, the implementation of an economically viable method of hydrogen distribution from largescale central production factories is essentially impossible.

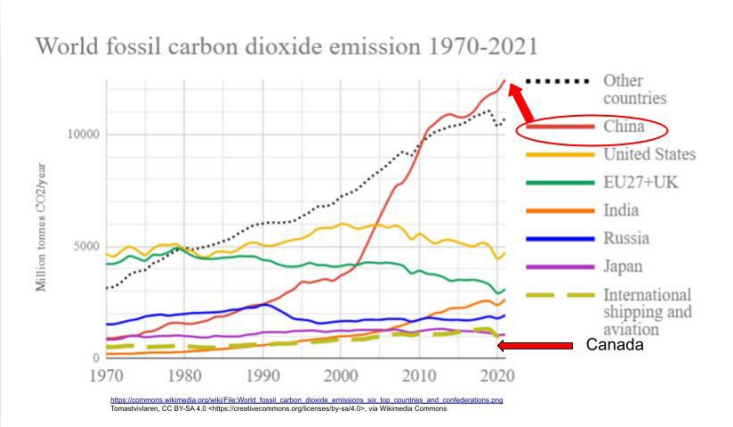
Conclusion

Complete decarbonization of Ontario's electrical energy system rests upon the rapid commercialization of many technologies that are either immature or simply not proven, such as hydrogen, carbon dioxide capture and storage, second generation biofuels, and small nuclear reactors. **The continued pursuit of present policy will not only raise prices to unheard of levels but it will lead to a future of rationing, oppressive regulations and economic decline.**

For about 32 years, electricity demand growth in Ontario has been sluggish, and for most of that time generation capacity has significantly exceeded demand, resulting in increased costs to consumers. Today's projections of much increased demand may indeed be misplaced; they certainly are based on a long series of assumptions, many of which could turn out to be false. The potential renewable energy and other supply choices being championed today by various self-interested groups would produce trivial emissions while operating, but have large up-front capital (and environmental) costs. Wind and solar energy cost far more than the alternatives. There is an alternative in preparing for a possible higher demand scenario that is low capital cost, and perhaps higher in operating costs. It is natural gas plants.

It should be apparent to anyone familiar with Ontario's electrical energy system that the costs that would be associated with decarbonization vastly exceed the benefits. In the period to 2030, the demand for natural gas to meet anticipated generation requirements might increase greenhouse gas emissions to a maximum of 12.2 million tonnes in 2030. In today's terms, that would be 1.7% of Canada's annual emissions, which are themselves only 1.5% of global emissions. As these levels are almost vanishingly small in the global context, the

avoidance of these emissions would have effects on the global emissions and temperatures that are too small to measure. This should make it obvious that these changes are being pursued for ideological reasons that have no connection to the alleged goal of avoiding adverse climate changes.



About the Author

Robert Lyman is an economist with 27 years' experience as an analyst, policy advisor and manager in the Canadian federal government, primarily in the areas of energy, transportation, and environmental policy. He was also a diplomat for 10 years. Subsequently he has worked as a private consultant conducting policy research and analysis on energy and transportation issues as a principal for Entrans Policy Research Group. He is a frequent contributor of articles and reports for Friends of Science, a Calgary-based independent organization concerned about climate change-related issues. He resides in Ottawa, Canada. Full bio.

About Friends of Science Society

Friends of Science Society is an independent group of earth, atmospheric and solar scientists, engineers, and citizens that is celebrating its 22nd year of offering climate science insights. After a thorough review of a broad spectrum of literature on climate change, Friends of Science Society has concluded that the sun is the main driver of climate change, not carbon dioxide (CO_2).

Friends of Science Society

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