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Renewables-based Distributed Energy Resources in Ontario: A Three-Part Series of Unfortunate Truths

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Council for Clean & Reliable Energy
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Disclaimer

The views expressed in this CCRE publication are those of the author, not the CCRE, and are based on the comprehensive analyses undertaken for Distributed Energy Resources in Ontario: A Cost and Implications Assessment, June 2018, commissioned by Ontario's Nuclear Advocacy Committee and the Power Workers' Union.

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Renewables-based Distributed Energy Resources in Ontario: A Three-Part Series of Unfortunate Truths

Part 2: Ratepayer Cost Implications

Marc Brouillette

Currently, in Ontario there is widespread debate about whether renewables-based distributed energy resources (DER) can meet the province's future electricity needs. Advocates posit wind and solar as low-cost, low-emission supply alternatives to fossil fuels and the basis for a 100-percent renewables future. Indeed, Ontario's 2017 Long-Term Energy Plan (LTEP) places significant reliance upon renewables-based DER to address an expected shortage in the province's electricity supply over the next five to 15 years. Unfortunately, the intermittency of wind and solar resources resulting from Ontario's climate and geography undermines this potential. These issues are being explored in a three-part series of CCRE Commentaries that examines the nature of renewables intermittency, the cost implications of renewables-based DER and DER's impact on Ontario's economy. This second Commentary explores the cost implications of pairing storage with intermittent renewables and demonstrates that renewable-based DER could be twice as costly as alternative nuclear and natural gas-based solutions.

"DER can differ significantly depending on scale and deployment"

CONTEXT

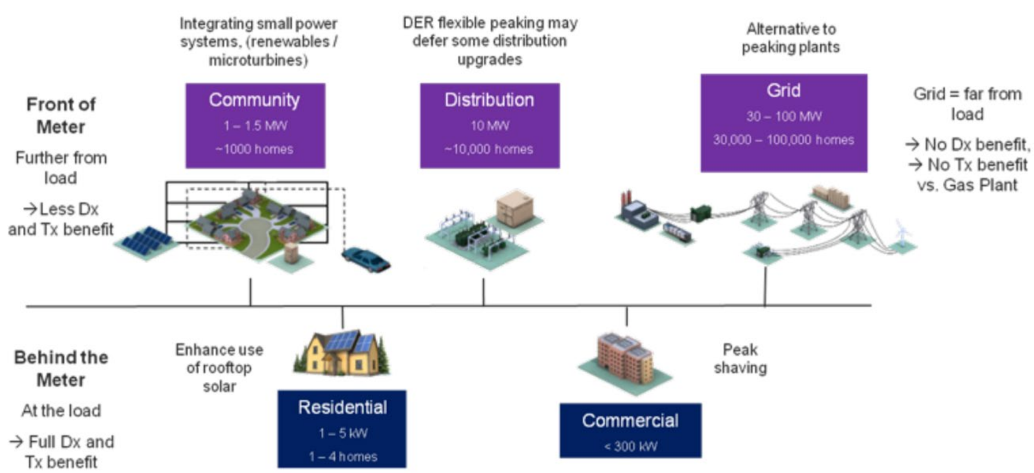
The declining costs of renewables and energy storage suggest they are becoming cost competitive with fossil fuels. However, two other important factors that impact the cost of DER challenge this assumption.

1. Renewable and storage costs vary significantly, depending upon the application's scale; i.e., small-scale residential installations, such as rooftop solar, have a higher overall cost compared to larger grid-scale solar or wind farms.
2. Storage efficiency, which influences the need for backup natural gas-fired generation, is impacted by renewable intermittency. Higher supply intermittency means lower storage efficiency, and greater cost.

GRID-SCALE VS. COMMUNITY-SCALE DER PROJECTS

DERs can differ significantly in scale and deployment depending on whether they are "behind-the-meter" or "in-front-of-the-meter" (Figure 1).[1]

Figure 1 – DER Deployment Options



Source: Strapolec DER Report.

[1] See Strapolec DER Report (2018) and Lazard (2017).

Behind-the-meter installations include residential and commercial systems on the consumer's premises. These are typically small, with capacities of one kW to five kW for a single home, and up to 300 kW for commercial applications.

In-front-of-the-meter applications can range in size from community-scale to large-scale distribution (Dx) or transmission (Tx) grid-connected systems. Community installations typically have a generation capacity of about one MW, while larger grid-scale capacities typically exceed 30 MW.

With electricity generation in close proximity to the user, community-scale DER has the potential to smooth daily demand on the grid, thereby offer Dx and Tx benefits from less variability in demand helps optimize Dx/Tx system capacity factors and reduce costs.

This Commentary assesses three front-of-the-meter DER options, two of which are renewable-based.

1 Solar-based DER: A community-scale installation to time-shift solar output using co-located lithium-ion (li-ion) batteries that enables Tx/Dx asset optimization.[2]

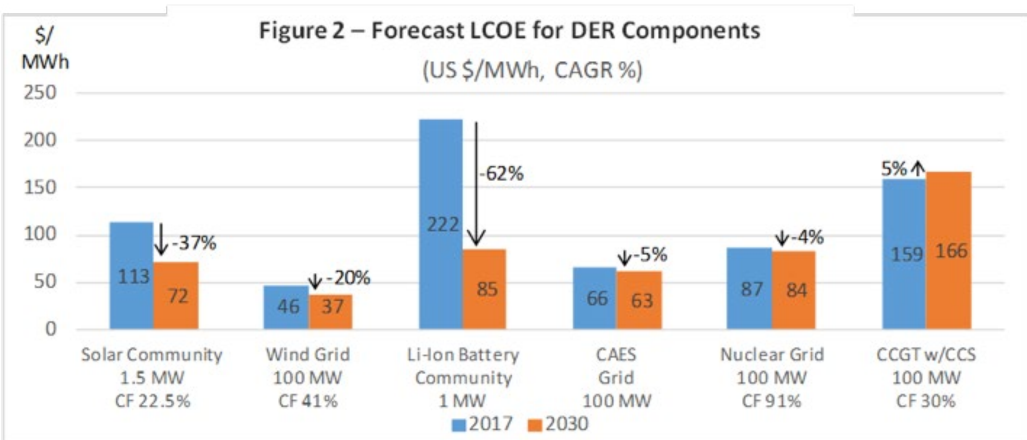
2 Wind-based DER: A grid-scale solution to time-shift wind energy output using co-located compressed air energy storage (CAES).[3,4] There are no anticipated Tx/Dx benefits beyond what would be expected of a grid-connected natural gas-fired generation.

3 Nuclear-based distributed energy storage (DES): Grid-scale nuclear coupled with distributed storage at the community level. Modest Tx/Dx benefits may be expected.

"Forecast declines in storage costs underpin DER with solar or nuclear"

FUTURE COSTS OF DER COMPONENTS

The levelized cost of electricity (LCOE) is used to compare costs of alternative generation options.



Note: Currency in real $2017, CAGR is Compound Annual Growth Rate, CF is the Capacity Factor.
Source: Strapolec analysis of EIA, NREL, Lazard data.

The LCOE for renewables and battery storage is expected to decline by 2030 (Figure 2).[5]

[2] Li-ion batteries are assumed, due to their low loss factor and deployment flexibility. Residential scale systems are expected to remain uneconomic for the foreseeable future

[3] A grid-scale wind-based DER is relevant for two reasons: 1) currently, Ontario's wind generation capacity is predominantly comprised of large grid-connected installations; and 2) small community-scale installations are expected to remain uneconomic in the foreseeable future due to siting and installation considerations.

[4] CAES is the lowest cost storage option, best co-located with grid-scale wind farms.

[5] These estimates are based on Strategic Policy Economics DER Report (2018) containing analysis of Energy Information Administration (2017), Lazard's Levelized Cost of Storage Analysis (2017), Lazard's Levelized Cost of Energy Analysis (2017) where projected values are associated with specific capacity factor assumptions for annual energy production.

- Solar: Community-scale solar LCOEs are expected to decline 37 percent by 2030, reaching US$72/MWh, assuming an average output of 22.5 percent of capacity – the capacity factor (CF).[6,7]
- Wind: Grid-scale wind LCOEs are expected to decline approximately 20 percent by 2030, reaching US$37/MWh, assuming an average 41 percent CF.
- Battery Storage: The LCOE for community-scale li-ion batteries is expected to decline 62 percent by 2030, falling to US$85/MWh assuming daily full charge/discharge cycles.[8]

In contrast, costs for nuclear, natural gas and CAES are expected to remain relatively stable through 2030. Of note, the CAES used in the wind-based DER option is forecast to be approximately three-quarters of the cost of li-ion batteries.

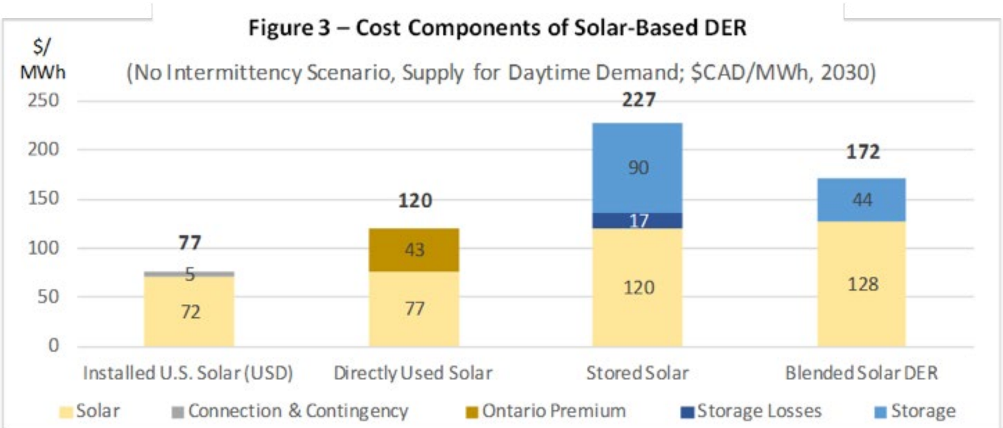
ADJUSTING COSTS TO ONTARIO

It is not always apparent that the low cost of renewables described in the media are in U.S dollars for U.S. installations. To make these costs relevant to Ontario ratepayers, the costs should be discussed in Canadian dollars (Figure 3). Ontario costs are influenced by higher supply and labour expenses for components and services sourced in Ontario and exchange rates affect the imported elements.[9,10]

However, the most significant cost contribution is weather-induced lower wind and solar capacity factors. For example, Ontario's solar capacity factor is approximately 17 percent as compared to the U.S. average of 22.5 percent, which increases Ontario's solar LCOE by 25 percent.[11] As a result of the aforementioned factors, the LCOE of new community-scale solar in 2030 is forecast to be $120/MWh, or about US$104, compared to US$77/MWh in the U.S.

"Despite cost declines, a solar based DER system will exceed $170/MWH"

However, more relevant is the LCOE for the integrated DER solution. For a solar-based DER to supply Ontario's expected demand profile, solar and storage components must be co-located and integrated.[12] The LCOE of the integrated DER system is the blended cost of the directly used solar energy and the stored energy (Figure 3). The cost of stored solar



Source: Strapolec analysis.

[6] Grid-scale solar is expected to drop to US$47/MWh by 2030. Residential-scale solar is forecast to remain above US$90/MWh by 2030 due to its small scale and lower average capacity factor.
[7] All dollars are Canadian, unless otherwise specified.
[8] Costs assume that the storage system operates at its target design charge/discharge cycle on a daily basis. For residential-scale systems, LCOEs will exceed US$400/MWh, ruling them out from consideration.
[9] Based on proxies to U.S. Energy Information Agency (EIA) benchmarks of how construction/installation capital costs vary by region, domestic portions of Ontario solar installations are estimated to be 16-percent more costly than in the U.S.; wind is 10 percent and storage three percent more costly.
[10] Long-term exchange rate assumed is one U.S. dollar equals 1.15 Canadian dollars.
[11] This estimate is based on actuals from IESO and the EIA. If the same cost asset produces 25-percent less energy due to its smaller capacity factor, then the cost per unit of energy, the LCOE, will become 25-percent higher. Wind has an estimated 32-percent capacity factor in Ontario compared to 41 percent in the U.S., increasing Ontario's wind LCOE by 21 percent.
[12] Assumptions include: solar-plus-storage system is designed to supply Ontario's average September incremental daytime demand; storage is sized to capture 52 percent of solar energy to charge the battery, discharging 45 percent after conversion losses; and demand reflects 2035 forecast using 2017 LTEP assumptions.

energy is the sum of the cost of the solar energy put into storage plus the cost of the storage system itself, including energy conversion losses. For Ontario, the LCOE of solar energy output from storage is expected to be $227/MWh.[13]

When the costs of the directly used solar energy and the solar energy output from storage are blended, the 2030 LCOE of solar-based DER is estimated to be $172/MWh. This does not include the cost impacts of generation and demand intermittency.

TOTAL ANNUAL GENERATION COST

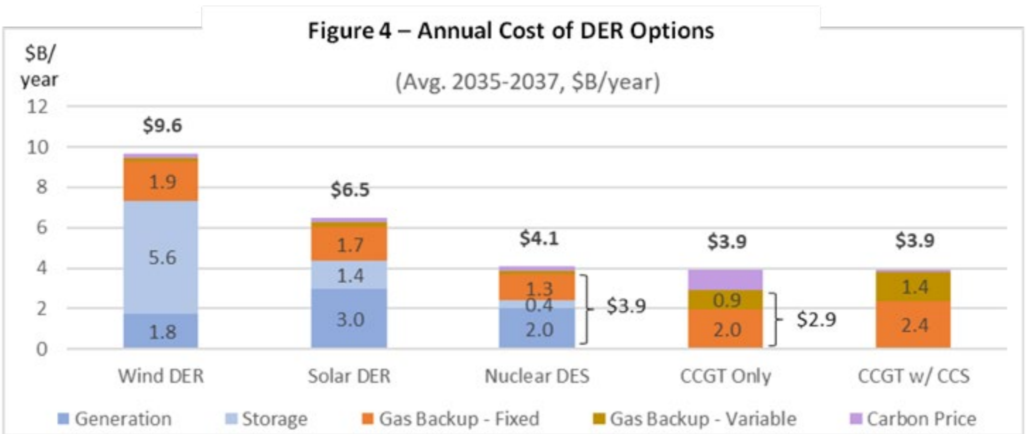
The first Commentary in this series assessed the impact of intermittency on DER options. It identified the generation and storage capacities required to meet Ontario's future daytime demand that exceeds Ontario's clean baseload supply capabilities. It concluded that DER or DES options require not only the relevant wind, solar, nuclear and storage capacities but also supplemental natural gas-fired generation.

Using forecast DER and DES costs, the lowest cost solution is nuclear-based DES (Figure 4). Solar-based DER is 60-percent more costly while the wind-based DER option is more than double the nuclear DES cost, primarily due to the large volume of required storage and the greater need for backup natural gas-fired generation.

"Intermittency makes a solar option 50% or $2.5B/year more colstly than a nuclear option"

For comparison, the lowest cost option would be a natural gas-fueled combined cycle gas turbine (CCGT). Absent a carbon price, this "CCGT Only" option is estimated to be $1B/year, or 22 percent less costly than the nuclear DES alternative. However, CCGTs produce emissions, thereby impacting climate change. Equipping the CCGT with carbon capture and sequestration (CCS) could reduce emissions – which would cost the same as the CCGT Only at a carbon price of $115/tonne.[14]

As DER/DES systems have low emissions, their costs would be marginally impacted by a price on carbon. At a carbon price of $115/tonne, nuclear-based DES costs marginally more than the CCGT options.



Source: Strapolec analysis and simulation of future Ontario hourly operation.

HYBRID OPTIONS: BALANCING SOLAR, WIND AND STORAGE

Hybrid wind-solar systems would take advantage of Ontario's high wind output in winter (when solar output is low) and high solar output in summer (when wind output is low). However, the costs of all hybrid options are more than the solar-only solution due to the much higher storage cost required to mitigate wind intermittency (Figure 5).[15]

[13] The cost of storage modelled here reflects cost-saving benefits from integrating the electronics of the solar panel with that of the storage device.
[14] Adding a carbon price on generation does not eliminate CO2 emissions. This requires DER and DES.
[15] The cost of a 100-percent renewable solution to eliminating the use of natural gas-fired backup is almost four times the cost of the nuclear DES option. The 100-percent renewables scenario modeled here still assumes that 3,000 MW of peaking natural gas generation is deployed for extreme peak demand days.

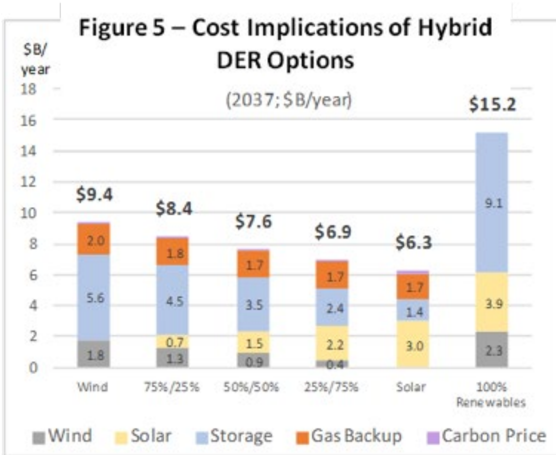


Figure 5 – Cost Implications of Hybrid DER Options

Source: Strapolec analysis.

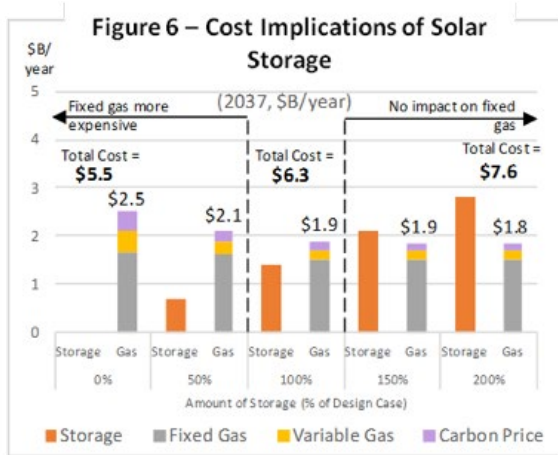


Figure 6 – Cost Implications of Solar Storage

Source: Strapolec analysis.

"No mix of wind, solar and storage improves the economics for ratepayers over nuclear"

As shown earlier, storage represents a significant cost for wind-based and solar-based DER options. However, varying the amount of storage has only a marginal impact on the need for natural gas infrastructure (Figure 6). The lowest-cost DER approach, absent a carbon price, would be to exclude storage, rely on natural gas-fired backup generation and allow surplus renewables output to be wasted. With greater need for natural gas-fired backup generation, the solar DER option without storage leads to higher emissions and is still more expensive than the nuclear DES option with storage.

DER OPTIONS DRIVE RATEPAYER COSTS HIGHER

For ratepayers, their electricity bill includes not only the cost of the daytime generation analyzed above but also the costs of baseload generation, peaking supply, reserve margin, Dx/Tx and regulatory charges (Figure 7). The nuclear-based DES option offers the greatest emissions reduction and a total bill that is 10-percent to 20-percent less than the solar and wind options. While the solar-based DER option offers a reduction in Dx/Tx capacity, saving $2/MWh, it is not enough to materially reduce ratepayer bills.[16] Assuming a carbon price of $115/tonne, only the status quo (SQ) and CCGT options cost ratepayers approximately the same as the nuclear DES option.[17]

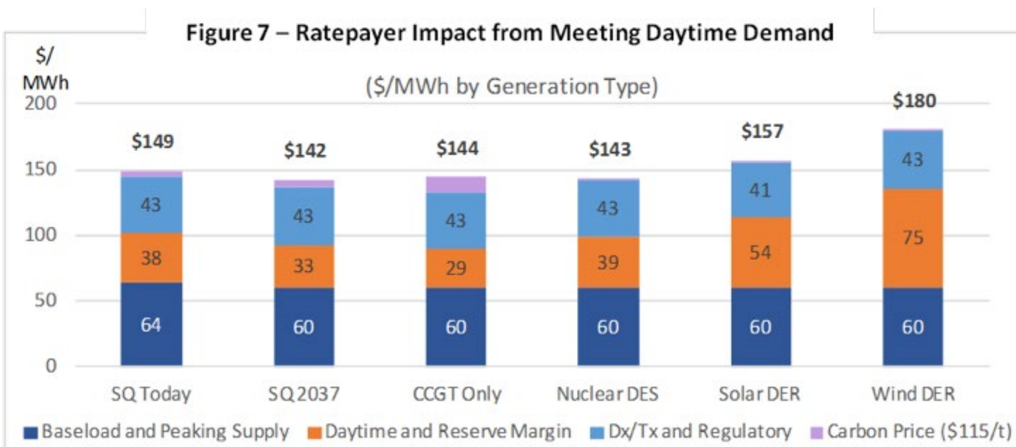


Figure 7 – Ratepayer Impact from Meeting Daytime Demand

Source: Strapolec analysis and simulation.

[16] Total costs here are extrapolated from Independent Electricity System Operator (IESO) quarterly energy reports and aligned with the IESO 2016 Ontario Planning Outlook (OPO) to estimate Dx/Tx and regulatory costs. Baseload supply costs extrapolated from the IESO 2016 OPO. Peaking gas supply costs based on IESO Market Renewal Program assumptions (2017).

[17] The status quo option uses the existing Ontario 2018 electricity supply mix to meet the 2035 demand. The nuclear option costs $1/MWh more than the status quo option, a difference of less than one percent.

SUMMARY

Renewables-based DER systems in Ontario could cost 60-percent to 230-percent more than an alternative nuclear-based DES option. These higher costs have the potential to increase ratepayer bills by 10 percent to 20 percent. At a carbon price at or above $115/tonne, nuclear-based DES offers the lowest, long-term cost with the greatest emissions reduction benefits and avoids increasing ratepayer bills. The next Commentary in this series will examine the economic implications of these choices for Ontario, including implications for the province's energy and economic competitiveness with the U.S.

"Next Commentary will examine the economic implications for Ontario"

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