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Solutions Paper No. 1

The Basics on Base Load:

Meeting Ontario's Base Load Electricity Demand with Renewable Power Sources

renewable is doable

the PEMBINA institute

Sustainable Energy Solutions

Roger Peters
Cherise Burda

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About the Pembina Institute

The Pembina Institute creates sustainable energy solutions through research, education, consulting and advocacy. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses. The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy and environmental governance. More information about the Pembina Institute is available at http://www.pembina.org or by contacting info@pembina.org.

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Introduction

The purpose of this solutions paper is to describe how Ontario’s base load power can be met through the deployment of renewable energy (RE) and energy efficiency (EE) technologies as presented in The Pembina Institute and WWF-Canada’s *Renewable is Doable* report under green scenarios.

This *Renewable is Doable* solutions paper addresses the misconception of the Ontario Power Authority (OPA) that large-scale nuclear or coal generation is required to meet Ontario’s residual base load demand for electricity. It argues that it *is doable* to put the right technical, regulatory and policy tools in place to make renewable power the primary source of power for the future.

Other jurisdictions that are leading the way in using RE technology as base load power are also presented here.

What is the Difference Between Base Load and Peak Demand?

Some power uses such as cooking, heating and lighting have daily and seasonal peaks. Utilities respond to this ***peaking*** of power demand by, a) encouraging consumers to shift or reduce their demand at peak periods, b) using power plants that can be dispatched (switched on and off) quickly when needed, and c) importing power from neighbouring utilities.

Base load power demand, on the other hand, results from continuous uses of electricity from such things as refrigerators, freezers and industrial motors where there are not defined peaks in use. Base load demand is met by reducing overall demand through energy conservation programs and then meeting the residual power demand from the grid.

“Demand response” programs aimed at reducing *peak* demand do not reduce overall demand, but, rather, shift the demand to non-peak times (like a waterbed effect). As base load demand is not reduced, overall energy use and gains remain unchanged. On the other hand, energy efficiency, fuel switching and co-generation initiatives can significantly reduce base load requirements.

How Do We Meet Residual Base Load Power Demand from the Grid?

In Ontario we have come assume that (residual) base load power demand can and should be met only by using continuously running thermal power plants like nuclear and coal and some hydro capacity. However, this is misguided. Any combination of variable and dispatchable power plants can be used to meet base load as long as together they provide a reliable continuous power supply for all parts of the province.

In fact, using nuclear plants as the primary base load supply can be a liability. Nuclear plants do not have a good record of reliability and take days to restart after a shut down. Major transmission lines are also needed to move power from core generation facilities to distant parts of the province. There are major headaches and expense for a utility if there are valleys in demand, unscheduled shut downs of nuclear plants or regional blackouts.

A distributed mix of smaller power sources could provide a more resilient method of meeting base load. In fact this study shows that gaps in base load can just as easily and effectively be filled with a mix of conservation programs, renewable energy, and natural gas cogeneration, waste heat recycling, storage and smart grid technologies and policies to enable effective deployment.

The Ontario Electricity Plan and Base Load

The Ontario government's *Supply Mix Directive* dated June 13, 2006 sets out the following priorities and goals in order of importance:

1, Use conservation and demand management (CDM) to reduce peak demand by 1,350 MW by 2010 and by another 3,600 MW by 2025.
2. Increase renewable generation to increase supply by 2,700 MW by 2010 and to a total of 15,700 MW by 2025.
3. Plan for nuclear power to meet base load requirements with but limit installed in-service capacity to 14,000 MW.
4. Use gas-fired generation as needed to meet peaking requirements and for applications that allow high efficiency use of this fuel.
5. Phase out coal-fired generation and replace it with cleaner resources at the earliest practical time.
6. Strengthen the transmission system to facilitate the development, use and integration of renewable resources.

The directive sets targets for conservation and renewable energy based on the minimum that must be achieved. However, Ontario Energy Board guidelines setting out how the directive should be interpreted, require greater quantities of conservation and renewable energy to be included in the plan if they are "shown to be prudent and cost effective against other resources". [1]

The final OPA 20-year integrated power supply plan (IPSP) submitted to the Energy Board in September 2007 interprets the directives restrictively and places limits on both CDM and renewable energy, thereby precluding their potential. In addition, both the supply mix directive and the IPSP suggest that CDM be used primarily for reducing peak demand rather than reducing overall base load demand.

The IPSP also calls for the full limit of 14,000 MW of nuclear capacity to meet base load. This is evident in the IPSP statement, "Nuclear power will be used to fill a significant gap (85 TWh by 2027) between the projected base-load demand and the planned capacity from other sources."

The following examples demonstrate how the IPSP arbitrarily caps conservation and renewable energy and discounts their full contribution to base load and potential to reduce nuclear capacity:

- The IPSP caps renewable energy and energy efficiency at levels far lower than their cost effective or maximum potential. Only 65% (25,800 GWh/yr) of achievable cost effective energy efficiency and fuel switching potential are to be acquired; both alternatives to nuclear could significantly reduce base load if maximized.
- The IPSP assumes that CDM is mostly acquired to reduce peak demand in the short term, rather than reducing overall base load in the short and long term.
- Wind generation is capped at 4,685 MW with no new capacity after 2020, even though 10,000 MW could be easily integrated into the current grid (and much more if new generator and storage technologies are used). This cap coincides with the decade it takes for new nuclear plants to be built and come online, precluding the need for continued development in renewable energy.
- Solar is capped at a minuscule 200 MW, even though Germany, with much less solar radiation than Ontario, installed 1,000 MW in 2006 alone.
- Significant opportunities to produce base load power from large and small scale cogeneration and waste heat recycling are left untouched; instead, the IPSP relies on the inefficient production of power using natural gas in stand-alone power stations.
- Imports of hydro-electric power from other provinces are suddenly stopped in 2019, again coinciding with the construction times of new nuclear plants.

We explore these shortcomings below in more detail.

Reducing Base Load Demand through Conservation and Renewable Energy

Renewable is Doable argues that base load demand could be met through conservation measures and renewable power sources without the need for coal or new and refurbished nuclear power.

1. CDM — Conservation, Energy Efficiency, Fuel Switching, Co-Generation and Waste Heat Recycling

The following table demonstrates that there is much higher potential to use energy efficiency, fuel switching, co-generation and waste heat recycling to reduce base load than is planned for in the IPSP.

Energy Savings Achievable by 2025

	IPSP TWh/yr	*Renewable is Doable* TWh/yr
Energy efficiency	17.4	35.0
Fuel switching	4.4	10.0
Micro-turbine cogeneration	4.2	6.5
Waste heat recycling	0.0	7.5
Industrial cogeneration	2.5	6.0
Total	28.5	65.0

This shows that with these sources alone the so-called significant base load gap of 85 TWh identified by the IPSP by 2027 has been narrowed to only 48.5 TWh.

The OPA itself reports that it is only pursuing 65% of the CDM potential it has identified as cost effective and achievable. In terms of cost effectiveness, the OPA estimates that it will spend $7 billion on conservation programs over the next 20 years, eliminating a cost of $15.9 billion to build and run generators to produce the energy that otherwise would have been used[2] — a savings of $2.27 for every dollar spent on conservation.[3] Doubling the contribution of conservation programs would not only close the base load gap but also save Ontarians millions of dollars.

2. Meeting Residual Base Load Demand with Renewable Energy

Once CDM is maximized and the base load gap reduced, *Renewable is Doable* showed that renewable power sources could meet the residual base load demand of 48.5 TWh. Detractors maintain that renewable power sources could never contribute to base load as their power outputs are intermittent, variable, not dispatchable and unpredictable. The longstanding argument persists that renewable energy must be backed up with conventional power sources, and that only a limited portion of renewable power sources can be integrated into Ontario’s grid. This assumes that the grid must be designed around central, large scale power plants, that renewable energy power will make the grid unstable, unmanageable and difficult to regulate and will reduce power quality.

All of these inferences are faulty and each is addressed in turn below.

Variability:

The outputs from wind and solar power sources do vary with wind speed and sunshine levels at a given location, but experience in other countries has shown that over a large geographic area there is much less variability (the wind is always blowing somewhere). By deploying wind and solar over a wide geographic area, variability is much reduced.

Renewable energy sources also tend to provide energy when it is needed to meet peak demand (wind in winter, solar in summer, hydro in spring), freeing up other dispatchable sources to contribute to base load.

Co-ordinating wind or solar power outputs with dispatchable hydro capacity (i.e., water storage and water-based imports) also allows a continuous non-varying output to be supplied to the grid.

Dispatchability:

Power storage systems are now making power sources such as wind and solar into dispatchable power sources. The addition of several hours of power storage can double the availability of a wind farm and also improve the quality of power fed into the grid (see below). Power storage systems already being used, commercialized or tested include

- pumped water storage (water is pumped into an existing or new reservoir and produces power when needed through existing or new turbines)[4]
- advanced battery storage (using “flow through” battery technology; e.g., Vanadium Redox Battery)[5]
- compressed air storage (air is compressed using RE electricity and used to run a turbine generator when needed) (the same generator can use natural gas combustion)[6]
- hydrogen storage (RE power is used to produce hydrogen by electrolysis; this hydrogen is stored and then used as need to produce power using fuel cells).[7]

Storage also overcomes the problem of predicting temporal behaviour of wind farms allowing day-ahead contracts to be offered. By adding 2 MW of flow battery storage to 12 MW of wind capacity, capacity factors can be improved by 16%, and peak effectiveness by 78%.[8] Finally, use of storage reduces the size of the transmission connection to the wind farm or solar facility, as it is the average output from the facility, rather than the peak output, that has to be accommodated.

Storage technologies will add cost to a renewable power source, but could easily turn out to be less costly than new generation nuclear plants or clean coal plants with carbon capture and storage.[9] Storage units can also be installed in small increments providing flexibility and a manageable cash flow.

Predictability:

Modern weather forecasting methods, electronic controls and communications mean that the output of any wind, solar or other renewable power source can be predicted hours and even days in advance so that a grid manager can plan the dispatch order in advance.

Integration:

In reality, with today's communications and control technologies to run "smart grid," utilities in other parts of the world are finding that a grid based mainly on renewable power sources will be no more difficult to control or regulate than current grids.[10]

Other innovations are making integration easier:

- new wind power generators are more "grid friendly" and produce higher quality power[11, 12]
- prediction of RE power output has improved (see above)
- regulatory reform based on new smart grid control technologies is being established.

In a report for the OPA, General Electric Wind showed that over 10,000 MW of wind could be incorporated into the Ontario grid without more than minor changes to either the grid itself or the regulatory regime.[13] This assumed limited use of power storage and today's wind power technology. *Renewable is Doable* shows that with the use of storage this could be easily raised to 15,000 MW or more.

The *Renewable is Doable* study showed that with significant reductions in base load and peak demand through CDM, far more of Ontario's future base load power demand could be met from renewable power sources — hydro (including imported), wind, solar (both rooftop and "greenfield") and biomass.

Projected Power Generation from RE and Imports by 2027

	IPSP TWh/yr	*Renewable is Doable* TWh/yr
Hydro	40.2	46.0
Wind	11.1	37.0
Solar	.3	3.6
Biomass	1.3	2.3
Hydro imports	0	21.8
Total	52.9	110.7

This effectively meets the OPA's projected base load gap with power to spare.

In terms of cost, the WADE modeling in the *Renewable is Doable* reports show that renewable power sources designed to meet base load are not any more expensive than Nuclear. Moreover, the substantial savings realized through maximizing conservation bring the cost down further, as conservation and energy efficiency are the least expensive way to generate ‘new supply. Overall, *Renewable is Doable* shows that if the cost of power from nuclear capacity is adjusted for historic performance of reactors and the increasing cost of refurbishment, the cost of electricity in 2027 from a CDM/renewable power future as outlined above is less than the one planned by OPA in the IPSP — 0.119 versus $0.124/kWh.

***Renewable is Doable* and Other Jurisdictions**

Once a decision has been made to maximize CDM and make RE power the primary base load source of the future, steps can be taken to put the technical, regulatory and policy tools in place to bring this about. Currently, Ontario is not a leader; other jurisdictions are showing the way.

A combination of CDM and renewable power sources have been proven effective as the primary source of energy meeting base load power demand in the following jurisdictions:

- Many jurisdictions such as British Columbia, Manitoba, the states of California and Vermont, and countries of the European Union are taking a much more aggressive approach to energy efficiency and conservation than is Ontario.[14] By leaving millions of kilowatt hours of efficiency gains untapped, we will waste billions of ratepayers’ dollars on unnecessary new power supplies. Ontario needs to focus more effort on CDM.
- California is one of the leaders in North America in integrating renewable energy into the grid. It has set up a task force to look at what is needed in the way of grid management, transmission optimization and regulatory reform to meet California’s renewable power targets.[15]
- Germany and Spain are showing how aggressive use of the feed-in tariff policy approach encourages rapid investment in RE power.[16] Ontario has introduced its Renewable Energy Standard Offer program — the first feed-in tariff in North America — but it falls far short of European policy. Now the state of Michigan is considering the use of feed-in tariffs that will be much higher than those offered in Ontario.[17]
- Some jurisdictions such as Ireland are encouraging the use off-power storage to increase the penetration of renewable power.[18]

Policy Recommendations to Meet Base Load Power Demand with CDM and Renewable Power Sources

There are no reasons why renewable energy sources, along with CDM initiatives, should not become the primary sources of Ontario's base load power demand. They are more flexible, less risky and more reliable than nuclear power, can be deployed more widely and quickly than nuclear power, and with the right grid integration, transmission, regulation, and acquisition policies, will provide a more reliable power source. Taken together, they will cost no more than nuclear power, and will result in a safer, cleaner power system.

To meet Ontario's base load demand without coal or nuclear power, the Pembina Institute recommends that Ontario begin by maximizing base load savings through realizing the full potential of CDM, and then maximizing renewable energy sources to meet base load requirements via key policy and technological tools.

1. **Maximize CDM to reduce base load demand and generate "new supply." Require OPA to pursue both peak and base load CDM savings at a level beyond the minimum in the current directive.**

We have shown in this paper that over 35,000 GWh/yr (35 TWh) of extra savings can easily be achieved through CDM, which means a 6000 MW reduction in the base load requirement**.**

A number of factors impede OPA from reducing energy demand and generating maximum "new supply" via conservation and efficiency. The 2008–2010 CDM portfolio focuses more on acquiring peak megawatt demand to meet short term targets rather than on energy efficiency measures that would reduce base load over the longer term.

There is also no overall leadership of conservation efforts in the Province. There are no long term targets or plans, no co-ordination between OPA programs and the setting of new codes and standards, and no indication as to where these OPA programs fit in the overall transformation of efficiency in each sector.

There is no reason why a 10,000 MW long-range CDM strategy focusing on both permanent base load and peak load reduction could not be put in place by 2010, modeled after experience in California, Vermont, New York or Texas. The current program looks only at what can be achieved easily in the next couple of years, rather than what needs to be both initiated and implemented in this time to achieve a long term base load demand reduction goal via a long term strategy.

The Pembina Institute recommends that the OPA and the Provincial government do the following:[19]

- Raise short term targets for the 2008–2010 CDM portfolio to at least the cost effective potential identified by OPA's own consultants — particularly for those programs that reduce base load demand, namely, energy efficiency, fuel switching and local generation.

- Develop a long-range plan that sets out a strategy, timelines, targets and key programs over the next 20 years for achieving permanent base load reduction.
- Establish explicit linkages between OPA CDM programs and the upgrading of energy efficiency codes and standards, particularly in the areas of lighting, air conditioning and new building construction.
- Facilitate a bolder portfolio that encourages the market transformation of electricity by developing "road maps" for each sector and hiring staff experienced in implementing comprehensive CDM programming.
- Expand the OPA Clean Energy Standard Offer Program to include a tariff for base load power production (i.e., not limited to peak hours).
- Support a training, certification and oversight initiative through regional training centres and a partnership among the Conservation Bureau, community colleges and contractor organizations across the province.
- Create an energy efficiency secretariat reporting to the Provincial Cabinet. This body would be tasked with co-ordinating energy efficiency activities among all implementing agencies in the province and developing a provincial action plan for transforming energy use in key sectors and end uses.
- Establish financial incentives and financing programs for residential solar water heating. This would be a new OPA CDM program and include low interest loans as well as rebates and/or tax incentives. The program should be complemented by solar water heater industry development, training and certification initiatives across the province.

2. Require OPA to maximize targets for renewable energy based on supply sources identified as achievable in *Renewable is Doable*, and pursue renewable supply sources at levels beyond the minimum targets provided in the current directive

The OPA should interpret the 2006 directive target not as a cap, but as a minimum target, and the OPA should be instructed explicitly to maximize renewable energy resources for base load before considering other power sources. The directive should explicitly require OPA to consider the environmental and social costs and benefits of all power sources.

3. Upgrade Ontario's groundbreaking Renewable Energy Standard Offer Contract (SOC) program so that it becomes the cornerstone of power system supply policy over the next decade.

To achieve the Province's renewable energy targets as quickly as possible, all caps on the SOC program should be lifted. At the same time the province should ensure that there is ample capacity in the distribution system for all community power projects seeking connection. Priority should be given to renewable power sources.

Specifically, the Province should lift the program size cap and voltage cap and raise tariffs for solar photovoltaic and other renewable power sources. Tariffs should include offering a premium incentive to systems that use storage to reflect the higher value of dispatchable power from renewable energy sources.

The following is a summary of recommendations for the SOC program made by the Ontario Sustainable Energy Association:

OSEA SOC Program Policy Proposal Summary		
	Immediate Corrective Action Needed	
	Current	**Action Needed**
Tariffs		
Solar PV	Tariff $0.42/kWh	Raise base tariff to $0.80/kWh
	No inflation adjustment	Add inflation adjustment
	Non-differentiated	Differentiate tariffs by size
		Grandfather existing contracts
On-farm Biogas	Tariff $0.11/kWh	Raise base tariff to $0.17/kWh
		Differentiate tariffs by size
		Grandfather existing contracts
Proposed Changes for Completion by March 20, 2008 Review		
Tariffs		
Wind onshore	Tariff $0.11/kWh	Raise tariff to $0.148/kWh
	Non-differentiated	Differentiate tariffs by resource intensity
	Inflation adjustment 20%	Increase inflation adjustment to 60%
Wind offshore	Not included	Add base tariff of $0.186/kWh
		Differentiate tariffs by resource intensity
Solar hot water	Not included	Add base tariff of $0.10 - $0.20/kWh
		Differentiate tariffs by application
Geothermal	Not included	Add base tariff of $0.224/kWh
		Differentiate tariffs by size
Policies		
Renewables	Not preferred resources	Priority access, Priority purchase
Project cap	10 MW	Eliminate cap
Voltage cap	50 kV	Eliminate cap
Anti-Gaming	None	Add anti-gaming provisions
LDCs	Uncertain cost recovery	Assure full cost recovery
Community renewables	Not preferred resources	Priority access, Priority purchase
Responsibility	No one person responsible	Name a chief renewable energy officer

4. Set up a Renewable Energy Integration Task Force

The role of this task force would be similar to the one set up in California to identify how to incorporate high levels of renewable power into the grid in terms of grid management, transmission optimization and regulatory reform. The task force would also identify best storage technologies and develop and implement storage integration strategies.

END NOTES

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[1] http://www.oeb.gov.on.ca/documents/cases/EB-2006-0207/IPSP_report_final_20061227.pdf , pp 5 -6

[2] www.powerauthority.on.ca/Page.asp?PageID=122&ContentID=6214&SiteNodeID=320&BL_ExpandID

[3] The savings from energy efficiency are even more striking - $9.7 Billion in savings from $3.45 billion in expenditures

[4] Ludington Pumped Storage discharges into Lake Michigan. Its 1872 MW can serve 1.4 million residential customers. The site has similar topography and climate to parts of Ontario; www.consumersenergy.com/content/hiermenugrid.aspx?id=31

[5] In the Vanadium Redox Battery (VRB), power is stored and recovered by passing this substance through an ion exchange membrane. The process is reversible, so the battery can be charged, discharged and recharged over and over almost indefinitely. Tests have confirmed that it is capable of more that 10,000 charge/discharges without any deterioration in efficiency. www.vrbpower.com

[6] The Iowa Stored Energy Park, near Fort Dodge Iowa, will use a pre-existing cavern to provide 200 MW storage for 100 MW wind capacity and off-peak coal, projected to be on-line by 2011www.isepa.com

[7] A US$2 million hydrogen-from-wind demonstration project has been launched by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and Xcel Energy. The most significant problem which they hope to solve is how to efficiently and cheaply convert the high voltage generated by a large wind installation to the lower voltage required by electrolysis, and to do it on a large, megawatt scale. Refocus Magazine, Jan/Feb 2007, official magazine ISES (International Solar Energy Association)

[8] *Flow battery Applications with Wind Power*, Mark Kunz, VRB Power Systems Inc. Presentation at California Energy Commission workshop on Meeting California's Electricity Challenges through Electricity Power Storage, February 24, 2005

[9] Sask Power recently shelved work on a clean coal power plant because its projected cost had almost tripled to $3.8 billion for a 300 Mw plant. *SaskPower shelves clean-coal project***,** Shawn McCarthy, Globe and Mail, September 6, 2007.

[10] *Distributed Generation, Renewable Energy and the Grid – A Policy Overview*. Alison Silverstein. ACORE/ABA/EBA Renewable Energy Teleconference. January 17, 2007

[11] *Impact on Past, Present, and Future Wind Turbine Technologies on California Grid.* BEW Engineering, California Energy Commission 500-2006-060, May 2006

[12] *Patently Innovative: Imagination in Wind Turbine Technology Continues to Flourish*. George March and Drew Robb, REFocus Magazine March/April 2007

[13] General Electric Wind prepared for Ontario Power Authority, IESO, and CanWEA. *Ontario Wind Integration Study*. October 6, 2006

[14] *Successful Strategies for Energy Efficiency: A review of approaches in other jurisdictions and recommendations for Canada.* Bailie, Peters, Zarowny and Horne. The Pembina Institute. 2000.

[15] *Intermittency Analysis Project: Final Report*. California Energy Commission 500-2007-081 July 2007

[16] *The Debate over Fixed Price Incentives for Renewable Electricity in Europe and the United States: Fallout and Future Directions*. Wilson Rickerson and Robert C. Grace for The Heinrich Böll Foundation, February 2007

[17] Under Michigan's new Renewable Energy Resources Bill – the first full-featured Feed Law introduced in the USA - prices for solar & biogas will surpass those in Ontario. http://www.legislature.mi.gov/(S(dbgzhjm1ydgbxqqwhfq1biv0))/mileg.aspx?page=getObject&objectName=2007-HB-5218

[18] *VRB ESS Energy Storage System and the development of dispatchable wind turbine output*. Feasibility study for the implementation of an energy storage facility at Sorne Hill, Buncrana, Co. Donegal. Tapbury Management Limited http://www.vrbpower.com/publications/media.html .

[19] For a full report and list of recommendations to the OPA's CDM portfolio please see: *Submission to the Ontario Power Authority on the OPA 2008–2010 CDM Program Portfolio* , August 24, 2007, prepared by Cherise Burda and Roger Peters, The Pembina Institute at www.pembina.org