CANADIAN ENVIRONMENTAL
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DE L'ENVIRONNEMENT*

Pembina Institute
for Appropriate Development

Towards a Sustainable Electricity System for Ontario

Interim Report

April 2004

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1. Introduction

The past five years have been a period of extraordinary change and upheaval in Ontario's institutions and policies related to electricity. More changes have occurred in the electricity sector since 1998 than over the preceding nine decades following the creation of the Ontario Hydro-Electric Power Commission (HEPC) in 1906.[1]

These changes have included the break-up of the HEPC's successor, Ontario Hydro, into four separate entities (Ontario Power Generation [OPG], Hydro One, the Ontario Electricity Financial Corporation [OEFC], and the Electrical Safety Authority [ESA]) through the *Energy Competition Act* of 1998. Under that legislation, competitive retail and wholesale electricity markets were introduced in May 2002, supervised by the Ontario Energy Board (OEB) and an Independent Market Operator (IMO). However, the competitive markets were partially terminated six months later in the context of high and unstable electricity prices.

In the meantime, from 1997 onwards, a significant portion of the province's nuclear generating facilities were taken out of service for safety and maintenance overhauls. This, in turn, led to an increased reliance on coal-fired generation to meet the province's electricity needs, a situation that has significantly exacerbated the severe air quality problems regularly experienced in southern Ontario. [2]

The new provincial government, elected in October 2003, has made a strong commitment to the phase out of OPG's coal-fired plants by 2007 due to the severe environmental and health impacts of their operation. The situation is further complicated by the consideration that all of the province's existing nuclear facilities,[3] which currently account for 28% of the province's generating capacity, will reach the end of their projected operational lifetimes by 2018.[4]

The combination of the projected end of life of the province's existing coal-fired and nuclear generating stations, and predictions of growing electricity demand have prompted a major debate over the province's future electricity needs, and how those needs might be met. The options proposed have ranged from ambitious energy efficiency programs accompanied by major investments in low-impact renewable energy sources, such as wind and small-scale hydro,[5] to the construction of a series of new nuclear generating facilities.[6]

2. The Pembina Institute/Canadian Environmental Law Association Sustainable Electricity Project

In this context of change and uncertainty, the Pembina Institute and the Canadian Environmental Law Association undertook a study to answer four key questions regarding Ontario's future electricity system. These were as follows:

1. How much might future electricity demand in Ontario be realistically reduced through the adoption of energy efficient technologies, fuel switching, cogeneration, and demand response measures?

2. How much future supply might be realistically obtained from low impact renewable energy sources, such as wind, the upgrading of existing hydroelectric facilities, and the development of new small-scale hydro plants, solar, and biomass?

3. How should the remaining grid demand, if any, be met once the technically and economically feasible contributions from energy efficiency, fuel switching, cogeneration, demand response measures, and low-impact renewable energy sources have been maximized?

4. What public policies and institutional arrangements should the province adopt to ensure the maximization of the contributions from efficiency and other demand side measures, low-impact renewable energy sources, and the most environmentally and economically sustainable supply mix to meet remaining future grid demand?

This interim report summarizes the study findings with respect to the first question. The study's overall findings and recommendations on the future shape of the province's electricity system will be released at the end of April 2004.

3. Assessing the Potential Impact of Energy Efficiency on Future Electricity Demand

In order to answer the first question, regarding the potential impact of energy efficiency programs, a series of generic policies was proposed to promote the adoption of energy efficient technologies, cogeneration in the industrial and commercial sectors, and fuel switching from electricity to natural gas (where this is the most efficient option). The impacts of these policies were simulated using the Canadian Integrated Modelling System (CIMS) computer model developed by the Energy and Materials Research Group at Simon Fraser University in terms of the following:

- the reduction in electricity consumption that could be achieved from the present to 2020 through the implementation of energy efficiency policies;

- the incremental investment associated with achieving the 2020 energy savings;
- the resulting changes in natural gas demand resulting from the adoption of energy efficient technologies and practices; and
- the net cost per kWh saved through energy efficiency measures.

An estimate of the reduction in peak electricity demand that would result from the reduction in electricity consumption identified through the CIMS model, and other measures that could be used to shift or reduce 2020 summer and winter peak demand, was then developed. Sectoral load factors were used to estimate the peak demand impacts of the CIMS results. The load-shifting potential of demand response measures such as time-of-day pricing were also considered.

Three types of policy intervention were simulated through the CIMS model:

1. The provision of financial incentives in the form of grants, sales tax removal, or tax credits for the adoption of the most efficient technologies and industrial processes.
2. The provision of innovative financing programs for high efficiency technologies and industrial processes to facilitate the faster payback of investments in these technologies and processes through energy savings.
3. The removal of barriers to cogeneration in the industrial and commercial sectors, through mechanisms such as net metering and power purchasing agreements.

The CIMS electricity consumption forecast by sector, assuming no change in parameters (business as usual), is shown in Table 1. Although there are some discrepancies between these forecasts and those of the IMO, particularly in the early years of the forecast, they are not large enough to affect the results of the analysis.

Table 1: CIMS Electricity Consumption Forecast by Sector—Business-as-Usual, 2005–2020

Sector		**GWh/Year**			
		2005	**2010**	**2015**	**2020**
Residential		37,926	36,674	38,430	40,535
Commercial /Institutional		55,279	64,885	76,226	89,489
Industrial	Process	12,709	12,749	12,912	13,049
	Auxiliary	33,440	33,950	36,072	38,269
	Cogeneration	(464)	(497)	(535)	(567)
TOTAL		138,890	147,761	163,105	180,775

The CIMS model uses the forecasts for electricity and natural gas prices for Ontario prepared by Natural Resources Canada (see Tables 2 and 3) to compute the life-cycle costs of competing technologies.

Table 2: Ontario Electricity Price Forecast (¢/kWh), 2000–2020

	2000	2005	2010	2015	2020
Commercial	8.30	8.50	9.22	9.98	10.79
Industrial	6.30	5.38	5.83	6.31	6.82
Residential	10.00	10.24	11.11	12.03	13.00

Table 3: Ontario Natural Gas Price Forecast ($/GJ), 2000–2020

	2000	2005	2010	2015	2020
Commercial	5.25	5.79	6.41	6.97	7.61
Industrial	3.61	3.97	4.40	4.76	5.18
Residential	6.37	7.01	7.76	8.46	9.25

The prices in Tables 2 and 3 are considered reasonable expectations in Ontario. While until April 1, 2004 the residential tariff was 4.3 cents per kWh,[7] the Ontario residential consumer was effectively paying in the range of 10 cents per kWh.[8]

4. The CIMS Results

Four CIMS simulations were carried out with the following policy assumptions:

Simulation 1: The removal of barriers to cogeneration

Simulation 2: The provision of financial incentives + the removal of barriers to cogeneration

Simulation 3: The reduction of discount rates (simulating the impact of innovative financing programs) + the removal of barriers to cogeneration

Simulation 4: The provision of financial incentives + the reduction of discount rates + the removal of barriers to cogeneration

The individual runs showed that lowering discount rates resulted in the largest reduction in electricity consumption, followed by cogeneration and financial incentives. This appears to be a reasonable result since the lack of means to finance the higher cost of energy efficient technologies out of the savings applies to all sectors and end uses. Financial incentives alone provide a benefit only if they bring the cost of the efficient technology close to that of conventional technologies. Cogeneration only applies to industry and larger commercial and institutional buildings. The three measures are not additive, but each tends to improve the chances of the others being successful. A small financial incentive, for example, will increase the likelihood of a consumer taking advantage of a financing program.

4.1. Impacts on Electricity Consumption

The CIMS electricity consumption forecast by sector, with all of the three policy changes in place, is shown in Table 4

Table 4: CIMS Electricity Consumption Forecast by Sector—Impact of Policy Changes, 2005–2020

Sector		**GWh/Year**			
		2005	**2010**	**2015**	**2020**
Residential		37,926	30,542	27,277	26,494
Commercial /Institutional		55,279	47,623	40,874	39,201
Industrial	Process	12,709	11,952	10,863	10,058
	Auxiliary	33,440	32,060	33,263	34,570
	Cogeneration	(464)	(1,282)	(2,173)	(3,047)
TOTAL		138,890	120,895	110,104	107,276

Energy savings achieved with the policy changes in place in each sector relative to the business-as-usual forecast are shown in Table 5.

Table 5: CIMS Energy Savings Forecast by Sector—Impact of Policy Changes, 2005–2020

Sector		**GWh/Year**			
		2005	**2010**	**2015**	**2020**
Residential		-	6,132	11,153	14,041
Commercial /Institutional*		-	17,262	35,352	50,288
Industrial	Process	-	797	2,050	2,991
	Auxiliary	-	1,890	2,809	3,699
	Cogeneratio n	-	786	1,638	2,480
TOTAL		-	26,867	53,002	73,499

* Includes small-scale on-site cogeneration as well as electricity efficiency and fuel switching

The CIMS results show that with the policy assumptions built in to the model for each sector, energy users would significantly change their purchasing habits with respect to energy-using equipment and processes. These changes would reduce business-as-usual electricity consumption by 73,499 GWh/year (from 180,775 to 107,276 GWh/yr) by 2020. This amounts to a 40% reduction against the business-as-usual forecast.

The electricity savings would result from three types of technological and behavioural changes:

1. The adoption of the most energy efficient technologies instead of conventional products in all sectors
2. The expansion of cogeneration in the industrial and commercial sectors, as energy consumers take advantage of the efficiencies offered by combined heat and power, generating power through cogeneration, and micro-turbines instead of buying from the grid
3. A shift from electricity to natural gas for heating in the residential and commercial sectors

These changes would be achieved as energy users would take advantage of financial incentives that reduce the capital cost of efficient or non-electric technologies, and innovative financing that would allow them to make purchasing decisions more on a life-cycle cost rather than a first-cost basis.

The overall results provided by the CIMS model should be viewed as an example of what could be achieved using the types of policies simulated. Actual strategies that might be used to obtain these savings will be proposed in the full report to be released in April 2004.

The CIMS results are conservative in nature. Many of the savings and cost advantages of new innovative approaches to efficient building design, such as integrated design, high-efficiency lighting management, and radiant cooling, have yet to be built into the CIMS model.

4.2. The Costs of Energy Efficiency Improvements

Table 6 provides a comparison of the incremental investment in energy efficient technologies and practices, the reduction in operation and maintenance costs resulting from these investments, and the net savings in energy costs assuming the energy prices given in Tables 2 and 3. All figures are discounted to 2004.

Table 6: Forecast Incremental Costs Associated with Achieving 2020 Energy Savings

Sector	**Incremental Costs Associated with Achieving 2020 Savings In millions of dollars (discounted to 2004)**			
	Investment	**Operation and Maintenance**	**Energy**	**Total**
Industrial	829	273	(1,255)	(153)
Residential	7,220	(45)	(6,174)	1,001
Commercial/Institutional	10,211	1,345	(11,782)	(226)
TOTAL	18,260	1,573	(19,211)	622

As Table 6 shows, the savings flowing from reduced energy consumption almost pay for the additional cost of the adoption of higher efficiency equipment. In fact, there are net benefits to commercial and industrial energy consumers.

Table 6 also shows a cost to residential consumers of efficiency investments of approximately $1 billion. This cost would amount to just over $90 per resident, spread over a 15-year period, or approximately $6 per person per year. However, in addition to energy savings, investments in the residential sector would carry with them significant co-benefits in terms of improvements in overall housing quality .

In essence, the savings in energy costs resulting from reduction in energy consumption will pay for more than 96% of the capital costs of the adoption of more efficient technologies over the long term. The net effect would be that even in the context of rising electricity and gas prices, the electricity costs to households and businesses would remain roughly the same as they are now, provided that consumers make the necessary investments in more efficient technologies and practices.

It is also important to note that the estimates of the savings resulting from investments in energy efficiency only consider the direct cost savings resulting from reduced energy use. They do not consider the economic, health, environmental, and social co-benefits that would flow from these investments. These co-benefits include the avoided environmental and health impacts of the construction and operation of generating facilities, improved housing quality, and the increased competitiveness of businesses and industries resulting from their more efficient use of energy resources.

In the case of health and environmental benefits, for example, the Ontario Medical Association has estimated that the total annual health costs associated with poor air quality in Ontario, to which the current electricity supply mix is a major contributor, is $9.9 billion per year.[9] The reductions in these costs from the avoided impacts of electricity generation that would flow from investments in efficiency measures would therefore be substantial.

The analysis also finds that Ontario's natural gas consumption would increase by 12% over business-as-usual projections by 2020 as a result of the technological and behavioural changes flowing from the measures tested through CIMS.

5. Translating the CIMS Forecasts into Reduced Peak Demand

The reduction in peak demand associated with the efficiency gains forecast through the CIMS analysis were estimated using load factors.[10] The results of this analysis are shown in Table 7.

Table 7: Estimated Peak Demand Reduction from Energy Efficiency Measures, 2010–2020

	2010 Peak MW	2015 Peak MW	2020 Peak MW
Contribution from Energy Efficiency, Fuel Switching, and Cogeneration	4,500	8,900	12,300

The analysis indicates that energy efficiency measures could reduce the province's peak electricity demand relative to the business-as-usual forecast by over 12,000 MW by 2020.

5.1. Demand Response

The study also considers the potential impact of demand response measures that encourage consumers to not use power at peak periods. This is done through pricing mechanisms designed to encourage customers to delay or manage power-using activities on an hourly or daily basis at critical peak periods. It can also be carried out through interruptible or ripple supply rates, where users agree to have non-key loads such as water heaters and battery charging shut off or supplied intermittently during peak periods. It has been estimated that up to 10% of Ontario's peak demand could be shifted through demand response measures.[11]

The total impact of the modelled energy efficiency measures and potential contribution of demand response programs on peak demand and net grid demand is shown in Table 8.

Table 8: Estimated Peak Demand Reduction and Net Grid Demand, 2010–2020

	2010 Peak MW		2015 Peak MW		2020 Peak MW	
	Winter	Summer	Winter	Summer	Winter	Summer
IMO Forecast for Peak Demand	26,000	27,800	26,500	28,700	28,000	30,000
Peak Demand Reduction from Energy Efficiency, Fuel Switching, and Cogeneration	(4,500)	(4,500)	(8,900)	(8,900)	(12,300)	(12,300)
Demand Response Measures	(2,330)	(2,330)	(1,980)	(1,980)	(1,770)	(1,770)
Net Grid Demand	19,170	20,970	15,620	17,820	13,930	15,930

This analysis indicates that net summer demand could be reduced by more than 45% against the business-as-usual forecast through the adoption of more energy efficient technologies, fuel switching, cogeneration, and demand response measures.

6. Comparing Energy Efficiency and New Supply Options

The study finds that capital investments of $18.2 billion over the 2005–2020 period would be required to achieve reduction in peak demand of 12,300 MW relative to the business-as-usual forecasts through efficiency, fuel switching, and cogeneration. However, 96% of these costs would be recovered by consumers through the savings in energy consumption resulting from these investments.

By comparison, providing the same amount of electricity supply through the construction of new nuclear generating facilities would entail a capital investment of over $32 billion.[12] In addition to avoiding these capital costs, a strategy focused on improving energy efficiency rather than adding new generating capacity would carry with it the benefits of the avoided costs of the saved electricity and gas as a result of energy efficiency measures. There also would be environmental, health, safety, and security co-benefits associated with avoiding the need to construct and operate the new generating facilities that would be required under business-as-usual scenarios. There would be overall improvements in housing quality and in the competitiveness of Ontario industry as a result of investments in more modern and efficient energy-using technologies as well.

7. Next Steps

Achieving the potential reductions in electricity demand identified in this report by 2020 will not be easy or without risk. However, other jurisdictions in North America are implementing the types of programs that will be needed in Ontario to achieve this target. California, for example, has reduced peak power demand by 20 per cent or 10,000MW over the past 20 years, with a combination of utility demand reduction programs and building and appliance standards.[13]

With the appropriate regulatory foundation in the form of minimum efficiency standards and labelling, OEB incentive mechanisms for utilities, and improved grid access for cogenerators, major reduction in electricity consumption can be achieved without excessive costs to government or energy consumers, or by penalizing low-income residents in Ontario.

A vision for an overall electricity framework, including supply options to address the remaining grid demand once efficiency, fuel switching, cogeneration, and demand response have been maximized, will be presented in the project final report at the end of April 2004.

Endnotes

[1] On the creation of the HEPC see N. B. Freeman, *The Politics of Power: Ontario Hydro and Its Government 1906–1995* (Toronto: University of Toronto Press, 1996), chapter 2.

[2] See, for example, Toronto Public Health, "Air Pollution Burden of Illness in Toronto: Summary Report" (Toronto: City of Toronto, May 2000).

[3] This includes the facilities not included in the 1997 Nuclear Asset Optimization Plan (NAOP): Pickering B; Bruce B; and Darlington; totalling 12 units and 8728 MW in generating capacity.

[4] Based on a 25-year projected lifetime.

[5] See, for example, R. D. Torrie and R. Parfett, "Phasing Out Nuclear Power in Canada: Towards Sustainable Energy Futures" (Ottawa: Campaign for Nuclear Phaseout/Torrie Smith Associates, July 2003).

[6] OPG Review Committee, "Transforming OPG" (Toronto: The Committee, March 2004).

[7] In November 2003 the government announced the abandonment of the fixed electricity price of 4.3 cents/kWh as of April 1, 2004, going to 4.7 cents/kWh for the first 750 kWh consumed and 5.5 cents/kWh for consumption beyond that level.

[8] When such factors as customer charges, distribution charges, transmission charges, wholesale operations charges, and debt retirement charges are considered, a typical average bill in the City of Toronto works out to 11.7 cents/kWh.

[9] Ontario Medical Association, "The Illness Costs of Air Pollution in Ontario: A Summary of Findings" (Toronto: Ontario Medical Association, June 2000).

[10] The load factor used in this study was 68%. The load factor was determined on the basis of this formula: Average demand (MW) = Total consumption (GWh) x 1000/Hrs per year Peak Demand = Average Demand/Peak Load Factor, and applying this formula to the IMO forecasts of electricity consumption and peak demand.

[11] For more information on demand response measures and their potential impact on peak demand, see Navigant Consulting, "Blueprint for Demand Response in Ontario" (Toronto: April 2003), prepared for the IMO.

[12] This estimated is based on a need for 15,375MW of capacity assuming an 80% capacity factor and Atomic Energy of Canada's proposal for eight 700 MW units at a total cost of $12 billion (i.e., $2.1million/MW).

[13] The Energy Foundation Utility Energy Efficiency Fact Sheet http://www.ef.org/national/FactSheetUtility.cfm