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Rolling the Dice:

A Review of the Ontario Power Authority's High-Risk Strategy to Meet Our Electricity Needs

Ontario Clean Air Alliance

FEBRUARY 9, 2007

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The Ontario Clean Air Alliance is a coalition of health, environmental, and consumer organizations, faith communities, municipalities, utilities, unions, corporations and individuals working for cleaner air through a coal phase-out and the shift to a renewable electricity future. Our partner organizations represent more than six million Ontarians.

Ontario Clean Air Alliance
625 Church Street, Suite 402
Toronto M4Y 2G1

Tel: (416) 926-1907 ext. 245
Fax: (416) 926-1601
E-mail: contact@cleanairalliance.org
Web Site: www.cleanairalliance.org

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Introduction

In a series of discussion papers and reports, the Ontario Power Authority (OPA) has outlined its draft strategy to meet Ontario's electricity needs over the next 20 years.

According to the OPA, its proposed strategy is a low-cost, low-risk strategy to phase-out coal, reduce our greenhouse gas emissions and meet Ontario's electricity needs. But a close review of the actual details of the OPA's proposed approach reveals a high-risk, high-cost strategy based on overly optimistic assumptions about the cost, performance and reliability of nuclear power and the ability of Hydro One to get regulatory and political approval to build the proposed Bruce Nuclear and East Toronto Transmission Lines. In addition, the OPA's strategy fails to aggressively pursue the provincially mandated coal phase-out, as well as lower-cost, lower-risk energy conservation and efficiency, renewable, and combined heat and power options.

This report describes the key components and weaknesses of the OPA's strategy; and provides recommendations with respect to a quicker strategy to phase-out coal that provides greater certainty, and a lower-risk and lower-cost strategy to meet our electricity needs to 2025.

Electricity Supply

Table 1 shows Ontario's actual electricity mix in 2005 and the OPA's proposed electricity mix for 2025.

Table 1: Ontario's Electricity Mix: 2005 and 2025

	Ontario's Electricity Mix - 2005[1]	OPA's Proposed Electricity Mix - 2025[2]
Nuclear	51%	53%
Renewable	22%	31%
Coal	19%	0%
Natural Gas/Oil	7%	14%
Other	1%	2%

Key features of the OPA's proposed electricity mix for 2025 include the following.

- Nuclear power will meet 53% of our electricity needs in 2025, up from 51% in 2005.
- All of our nuclear electricity in 2025 will come from just three generating stations (Bruce, Darlington and Pickering).
- While renewable generation is up in 2025, it is still substantially less than nuclear generation.
- New natural gas-fired combined heat and power (CHP) generation, a sub-component of "Natural Gas/Oil" generation, will provide only 4.3% of Ontario's total electricity supply in 2025.[3] Natural gas CHP uses natural gas to simultaneously produce two services, i.e., heat and electricity. CHP can have an overall energy efficiency of 80 to 90% versus the 30 to 34% energy efficiency of our nuclear and coal-fired power plants.[4]

Table 2 provides a break-out of the OPA's proposed capital budget to 2025.

Table 2: Capital Cost of OPA's Electricity Plan to 2025

Conservation and Demand Management	**$5.73 billion[5]**	**7.8%**
Nuclear	$35 billion[6]	47.4%
Renewable	$18 billion[7]	24.4%
Natural Gas	$8.5 billion[8]	11.5%
Transmission	$6.68 billion[9]	9.0%
Total	$73.91 billion	

Key features of the OPA's proposed capital budget to 2025 include the following:

- More than half the budget (56.4%) is devoted to nuclear power and high-voltage transmission systems.
- Less than 10% of the budget (7.8%) is devoted to conservation and demand management.
- For every $1 that the OPA is planning to spend on conservation and demand management, it is planning to spend $12 on electricity supply.

New Electricity Transmission Capacity

The Bruce Nuclear Transmission Line

A key feature of the OPA's electricity plan for Ontario is to increase the output of the Bruce and Darlington Nuclear Generation Stations and build additional transmission capacity to deliver this power to the Greater Toronto Area (GTA).

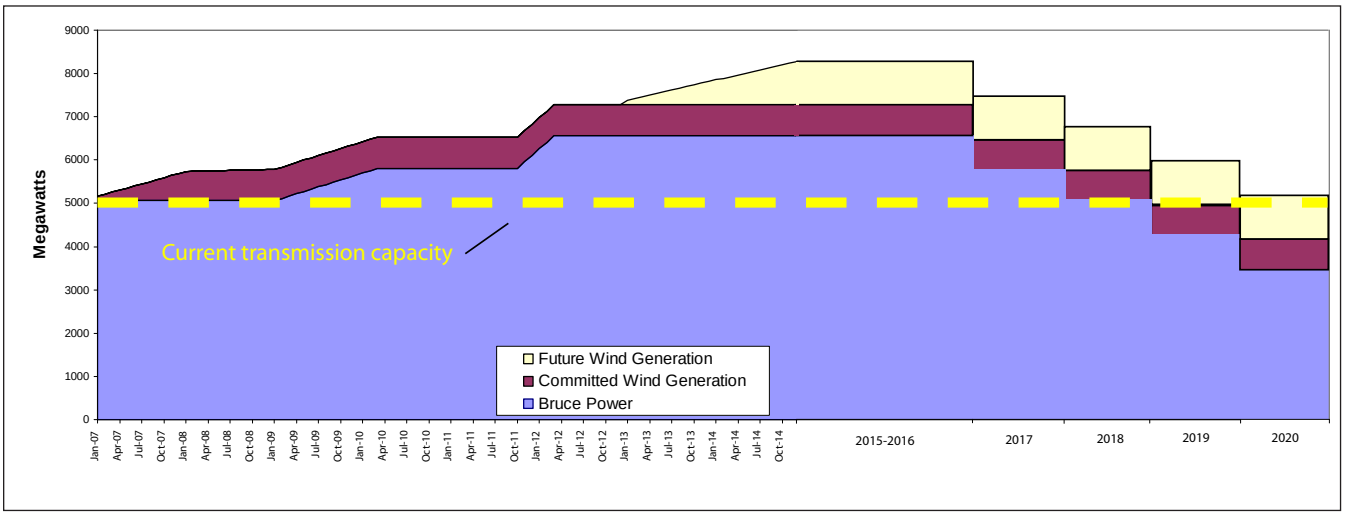
In October 2005 the OPA signed a contract with Bruce Power to:

a) Re-start the Bruce A Unit 1 and Unit 2 nuclear reactors. The reactors are targeted to re-start in 2009 and/or 2010;
b) Refurbish Bruce A Unit 3. The refurbishment is targeted to occur in 2010 and 2011; and
c) Replace Bruce A Unit 4's steam generation equipment. This is targeted to occur in 2007.

The OPA signed this contract despite the fact that Hydro One does not have sufficient transmission capacity to deliver this additional nuclear electricity to Ontario's consumers.

Figure 1 shows the forecast nuclear and wind generation capacity in the Bruce Peninsula from 2007 to 2020 and Hydro One's existing transmission capacity. The Bruce Peninsula's generation capacity is forecast to grow until 2014. Between 2017 and 2020, its generation capacity will decline by 785 MW per year as the

Fig. 1: Bruce Area Generation and Transmission[51]



four Bruce B nuclear reactors come to the end of their economic lives.

To meet the temporary gap between the Bruce Peninsula's generation and transmission capacity, the OPA is proposing that Hydro One take the following actions to increase the capacity of its Bruce to GTA transmission network.[10]

Table 3: Proposed Bruce Transmission enhancement measures

Facilities Description	Completion Date	Cost
Static VAR compensators and shunt capacitors in Southwestern Ontario	2009	$80 million
Upgrade 230 kV circuits from Hanover to Orangeville Transformer Stations	2009	$10 million
Upgrade Bruce area generation rejection facilities	2009	$10 million
Series capacitors on Bruce Generating Station to Longwood Transformer Station and Longwood Transformer Station to Middleport Transformer Station 500 kV circuits	2010	$100 million
Build a new 180 km 500 kV double-circuit transmission line from Bruce Nuclear Station to the GTA	2011	$600 million

The OPA's first four proposed options consist of relatively minor and low cost reinforcements to Hydro One's transmission system. As Figure 2 reveals, these minor reinforcements will increase the capacity of the Bruce Nuclear Transmission Line by approximately 50%. In the absence of new nuclear generation in the Bruce Peninsula, these minor reinforcements will provide the Bruce area with all the transmission capacity it needs except during a four year period between 2013 and 2017. To eliminate this four year gap and to facilitate the construction of new nuclear reactors in the Bruce Peninsula, the OPA is proposing that Hydro One build a new $600 million high-voltage transmission line from the Bruce Nuclear Station to the GTA by 2011.

Figure 2 shows the potential impacts of the OPA's proposals, excluding the proposal to build a new 500 kV transmission line, on Hydro One's Bruce Area transmission capacity.

Fig. 2: Bruce Area Generation and Transmission with minor transmission reinforcements[52]

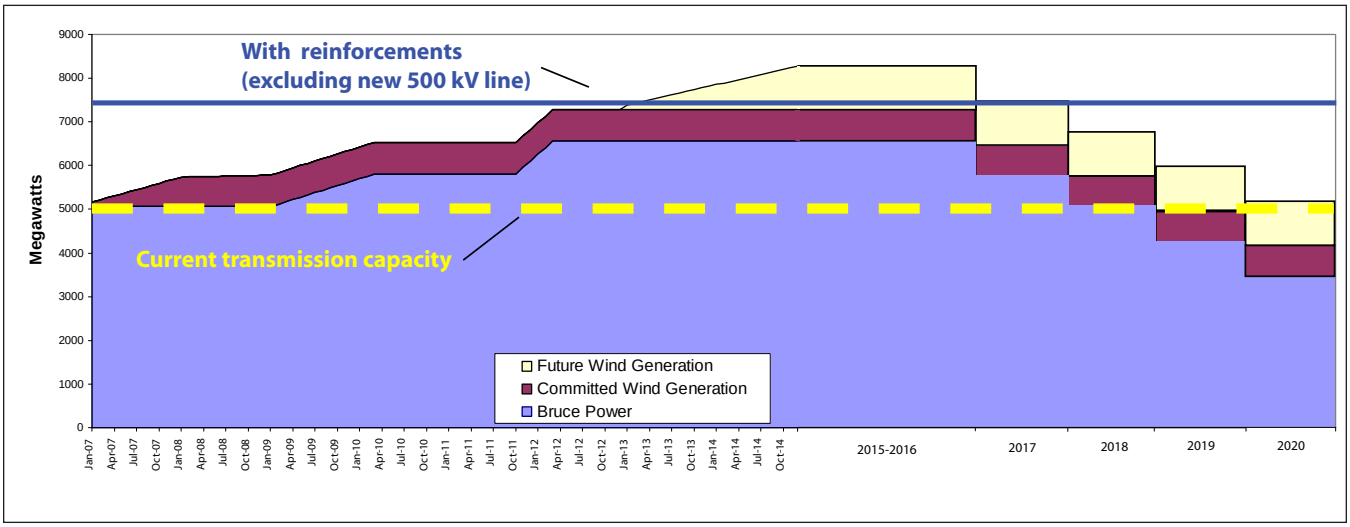
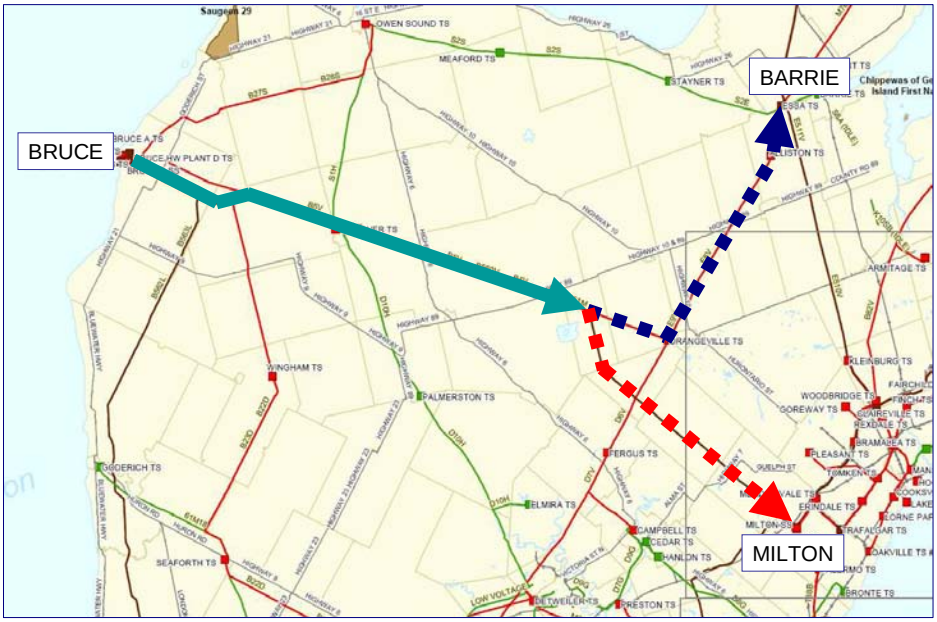


Figure 3 shows two alternative routes for the proposed new high voltage transmission line from the Bruce Nuclear Generating Station to the GTA.

Fig. 3: Bruce Area Transmission - potential routes[53]



The East Toronto Transmission Line

The OPA is also proposing that Hydro One build a new high-voltage transmission line to supply downtown Toronto. Its preferred transmission option appears to be through East Toronto from the Parkway Transformer Station in Markham (Highway 407 and Warden Avenue) to the Hearn Transformer Station on the Toronto waterfront. See **Figure 4**.

According to the OPA's plan, this 25 km $600 million transmission line should be completed by 2016.[11]

Fig. 4: Toronto third line[54]

Phasing Out Coal

Ontario's four remaining coal-fired power plants have a total capacity of 6,434 MW. The OPA is proposing to reduce Ontario's coal-fired generation capacity to:

a) 5,000 MW in 2011;
b) 3,000 MW in 2012; and
c) O MW in 2015.[12]

However, the OPA is reserving the right to announce that the coal plants should continue to remain in operation post- 2014 if new capacity is delayed (e.g., increased output from the Bruce Nuclear Generating station is unavailable and/or the proposed new Bruce to GTA high-voltage transmission line fails to be completed).[13]

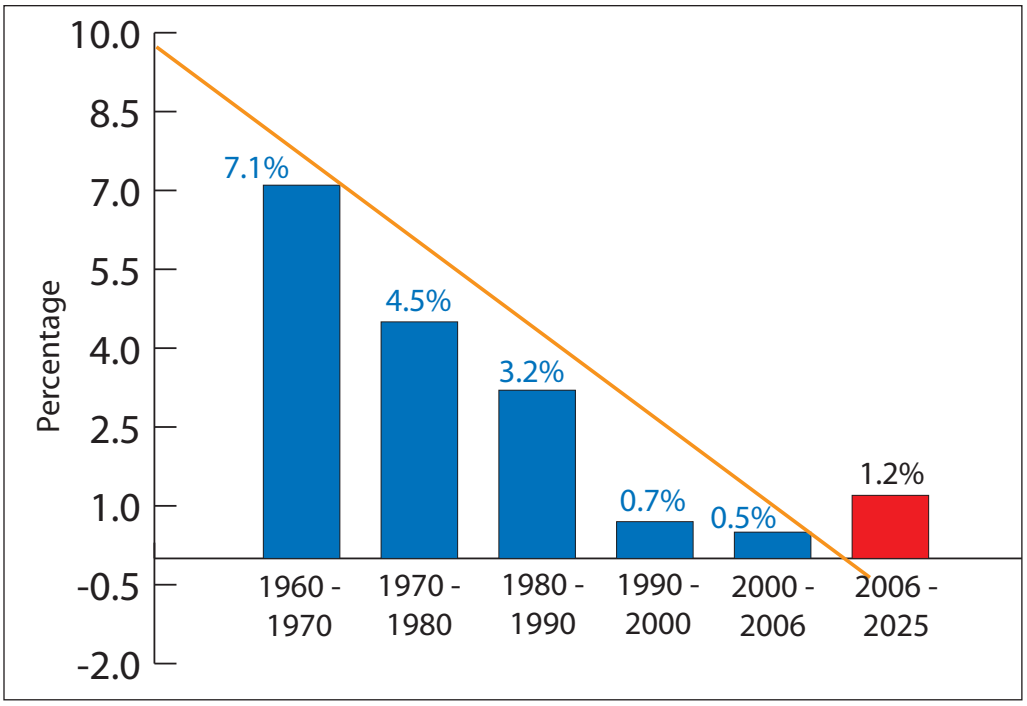
Ontario's coal-fired electricity generation has fallen from 36.3 billion kWh in 2003 to 25 billion kWh in 2006.[14] According to the OPA's projections, Ontario's domestic coal-fired electricity generation requirements will fall to 1 billion kWh in 2010 (less than 1% of Ontario's total electricity consumption). Nevertheless, the OPA is proposing that in 2010 OPG should generate 15 billion kWh of coal-fired electricity and export 14 billion kWh of surplus power to the U.S.[15]

Electricity Consumption Growth

Figure 5 shows Ontario's annual rates of electricity demand growth (kWh) from 1960 to 2006 and the OPA's forecast of electricity demand growth from 2006 to 2025.[16]

As Figure 5 reveals Ontario's actual electricity demand growth rates have fallen from 7.1% per year in the 1960s to 0.5% per year between 2000 and 2006. Nevertheless, despite this steady decline in Ontario's electricity growth rates, the OPA's analysis assumes that Ontario's rate of electricity growth between 2006 and 2025 (1.2% per year) will be more than *double* its actual rate of growth between 2000 and 2006 (0.5% per year).

Fig.5: Annual Electricity Demand Growth (kWh) — actual and OPA projected



A Needlessly Risky Plan

According to the OPA, its proposed plan is the lowest-cost, practical strategy to phase-out coal, reduce Ontario's greenhouse gas emissions and keep the lights on. In our view, the OPA's strategy:

1. is based on overly optimistic assumptions with respect to the capital costs, financing costs, performance and reliability of rebuilt or new nuclear power plants;
2. is based on overly optimistic assumptions with respect to Hydro One's ability to get regulatory and political approval to build the proposed Bruce Nuclear and East Toronto Transmission Lines; and
3. does not aggressively promote the coal phase-out and lower-risk, lower-cost options to meet our electricity needs, namely, demand response, energy efficiency, renewable energy, fuel switching and combined heat and power.

The result is that the OPA is proposing an unnecessarily high-risk, high-cost strategy to meet our electricity needs.

Optimistic Nuclear Assumptions

Nuclear Capital Costs

The OPA's analysis assumes that the capital cost of a new CANDU 6 nuclear reactor, $2,845/kW (2005 $),[17] will be 30% *less* than the actual historic capital cost, $4,085/kW (1993 $), of the last nuclear power plant, the Darlington Nuclear Station, built in Ontario.[18]

Actual Ontario Nuclear Capital Costs Are Always Greater Than Forecast

The OPA's assumption that the cost per kW of a new nuclear reactor will be 30% less than the actual historic cost of Darlington is very problematic for at least two reasons. First, in general, inflation has raised prices by 25% since 1993.[19] Second, in Ontario, the actual capital cost of building or retrofitting nuclear reactors has always been much greater than forecast.

- In 1983, Ontario Hydro estimated that the total capital cost of Darlington would be $4 billion. Its actual total cost was 3.6 times greater, at $14.3 billion.[20]
- In 1999, Ontario Power Generation (OPG) estimated that the total cost of returning Pickering A Unit 4 to service would be $457 million. Its actual cost was 2.7 times greater, at $1.25 billion.[21]
- In 1999, OPG estimated that the total cost of returning Pickering A Unit 1 to service would be $213 million. Its actual cost was 4.8 times greater at $1.016 billion.[22]
- Bruce Power estimated that the total cost of returning Bruce A Units 3 and 4 to service would be $375 million.[23] Its actual cost was 2 times greater, at $750 million.[24]

Financing Costs

The OPA's analysis assumes that the required real pre-tax rate of return on capital for a new nuclear power plant would be between 5% and 11%.[25] However, according to CIBC World Markets, Bruce Power's (Canada's only investor-owned nuclear power company) actual cost of capital is 30 to 70% higher than the highest required rate of return on capital (a real pre-tax rate of 11%) used by the OPA.[26]

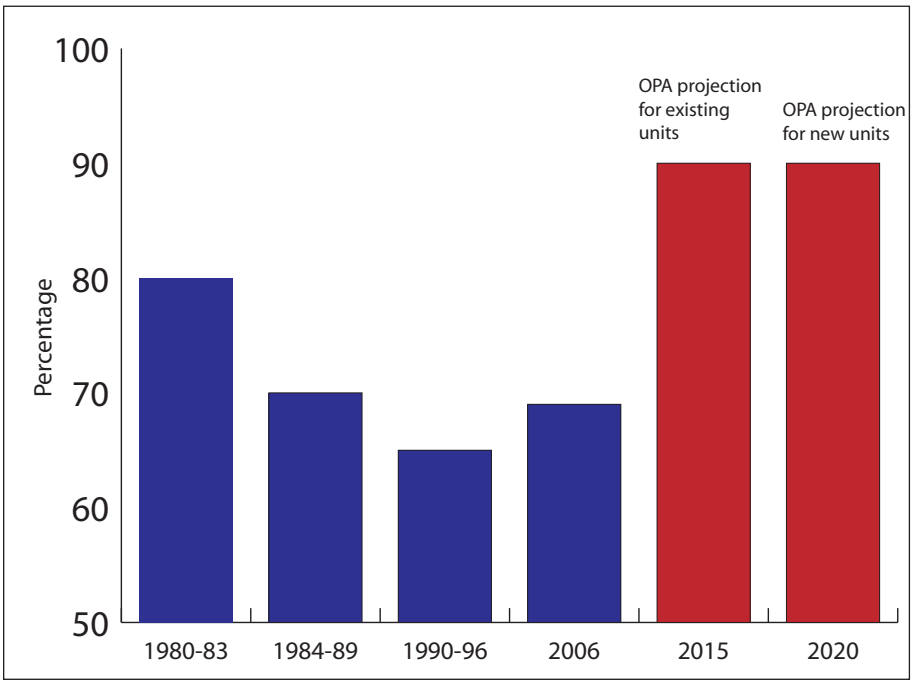
Annual Capacity Utilization Rates

The OPA's analysis assumes that the annual capacity utilization rates of our existing and new nuclear reactors in Ontario will be 90% in 2015 and 2020 respectively.[27] However, during the last 25 years the average capacity utilization rate of Ontario's fleet of nuclear reactors has never equaled 90%.

According to the Government of Ontario, the actual capacity utilization rate of Ontario's fleet of nuclear reactors declined from 80% between 1980 and 1983; to 70% between 1984 and 1989; and then to 65% between 1990 and 1996.[28] In 2006 the average capacity utilization rate of Ontario's fleet of nuclear reactors was 69%.[29]

As a result of the declining capacity utilization rates of Ontario's nuclear fleet, OPG had to increase the output of its coal-fired power plants by 117% between 1995 and 2003 to keep the lights on.[30] If Ontario's existing nuclear units are unable to achieve a 90% annual capacity utilization rate in 2015, will the OPA recommend that we continue to operate our coal-fired power plants to keep the lights on?

Fig. 6: Nuclear capacity utilization rates — actual and OPA projected



Reliability

As a result of Ontario's heavy dependency on CANDU nuclear reactors, it took Ontario more than 8 days to fully recover from the August 14, 2003 blackout versus less than 2 days for New York State.[31]

Greenhouse Gas Emissions

Table 4 shows the OPA's estimates of the life-cycle greenhouse gas emission rates per megawatt-hour (MWh) of electricity for: a) a coal-fired power plant with state-of-the-art end-of-pipe sulphur dioxide, nitrogen oxides and particulate matter emission control technologies; b) a natural gas-fired combined-cycle power plant; c) a wind turbine; and d) a CANDU 6 nuclear reactor.[32]

According to Table 4, the greenhouse gas emission rates of a natural gas combined-cycle power plant, a wind-turbine and a CANDU 6 nuclear reactor are 72%, 99% and 99% lower respectively than that of a coal-fired power plant.

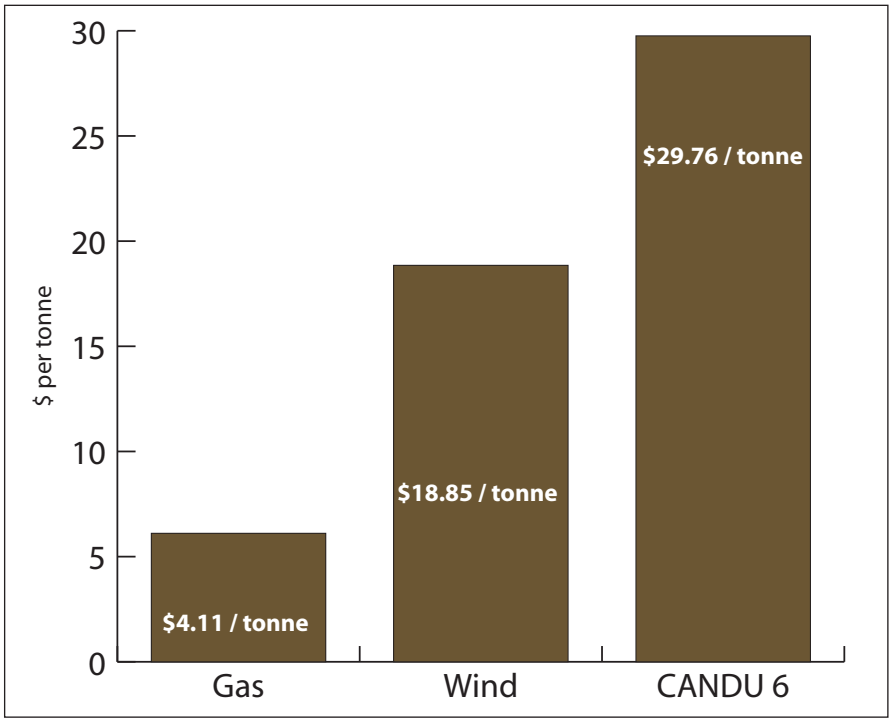
Table 4: Greenhouse Gas Emission Rates

Generation type	Greenhouse Gas Emission Rate (Kg per MWh)
Pulverized Coal Combustion Power Plant	1,020
Natural Gas Combined-Cycle Power Plant	290
Wind Turbine	12
CANDU 6 Reactor	12

According to the OPA's analysis, the cost per kWh of a new nuclear reactor is lower than that of a new natural gas fired power plant or a wind turbine.[33] Therefore, according to the OPA's analysis, nuclear power is a cost-effective option to phase-out coal and reduce greenhouse gas emissions.

However, as we have noted above, the OPA's nuclear cost analysis is based on numerous optimistic assumptions that do not correspond with Ontario's historical experience or market data. For example, according to CIBC World Markets, the financing costs for a nuclear reactor are 30 to 70% higher than the OPA's highest estimate. We asked the OPA to recalculate its nuclear costs using the CIBC World Markets' required rate of return on capital estimates while holding all its other cost assumptions constant. The result raises the cost of CANDU 6 nuclear electricity to 9.7 to 11.9 cents per kWh.[34] Figure 7 shows that new nuclear power plants are not a cost-effective option to reduce greenhouse gas emissions if the cost of nuclear power is 9.7 cents per kWh.[35]

Fig. 7: Comparative cost for greenhouse gas reductions



Failure to Aggressively Promote Alternative Options

Demand Response

Ontario's annual electricity system peak demands occur on the hottest days in the summer. There are four key characteristics of Ontario's peak day electricity demands.

1. The maximum peak day demands last for only very short time periods. For example, while Ontario's peak day demand in 2005 was 26,160 megawatts (MW), our electricity demand exceeded:
   a) 26,000 MW for only 4 hours in 2005 (0.046% of the time);
   b) 25,000 MW for only 53 hours in 2005 (0.6% of the time); and
   c) 23,544 MW for only 226 hours in 2005 (2.58% of the time).[36]
2. At the time of annual system peak, 38% of Ontario's electricity is being used for residential, commercial and institutional air-conditioning.[37]
3. The cost of supplying electricity on peak demand days is very high. Specifically, the cost of supplying electricity during the 90 hours of maximum annual demand (1% of the time) is greater than or equal to $1.36 per kWh. See Appendix A for a detailed break-out of these costs.
4. The cost of supplying electricity on peak demand days is dramatically higher than the price of electricity. For example, the cost of supplying peak day electricity is 14 times greater than the price of electricity for a Toronto Hydro residential consumer.[38]

Demand response programmes pay customers to shift some of their electrictiy consumption from peak to off-peak periods on peak demand days. According to a report commissioned by the OPA:

> "Demand response programs are a key way for all markets to reduce demand at crucial periods by providing economic incentives to consumers. Demand response has proved to be effective at addressing reliability issues as well as providing an economic way to avoid building additional capacity to address peak needs. Demand response can be a cost-effective policy tool, as illustrated by the high ratio of benefits to costs as measured by the NYPSC [New York State Public Service Commission]. Indeed, on a per kW basis, demand response is much cheaper than installing new peaking facilities…
>
> Even in the most active jurisdictions, demand response programs have only scratched the surface of what is possible; most customers are unaware of how they could participate or how they could reconfigure their operations to benefit."[39]

The OPA can cost-effectively reduce peak day demands by: a) paying our municipal electric utilities and Hydro One to cycle residential and small commercial central air-conditioners on and off during peak demand periods; and b) paying large volume commercial, institutional and industrial consumers on peak days, the same price to shift some of their consumption from peak to off-peak periods that it is willing to pay for peak day electricity supplies (i.e., at least $1.36 per kWh).

In 2006, Toronto Hydro introduced *demand response* programs to reduce its customers' peak day demands. Its Peaksaver program used radio signals to cycle

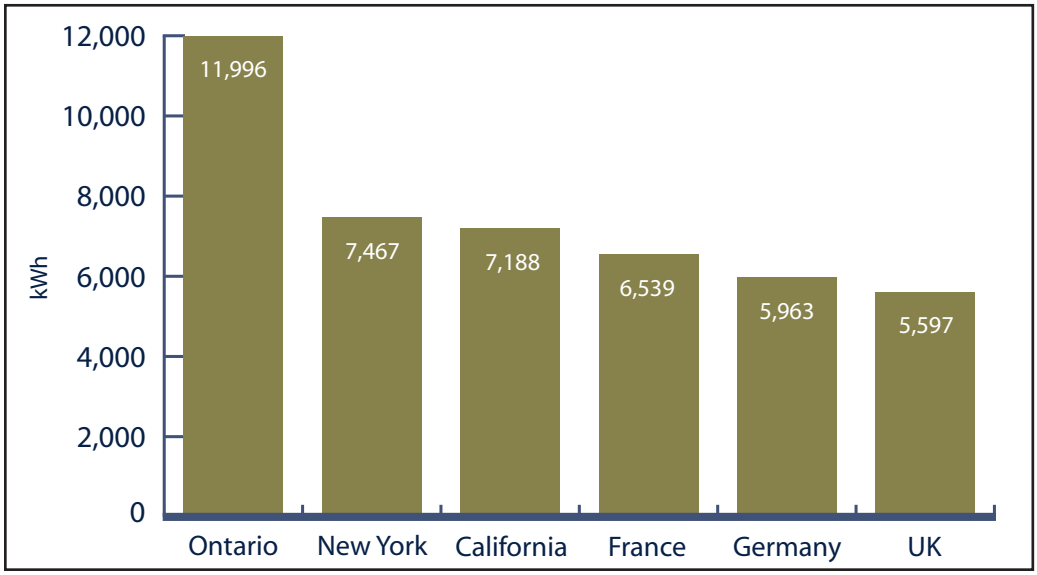
residential and small commercial central air conditioners off for 15 out of every 30 minutes during peak demand periods. Most customers did not even notice a difference since their air conditioner fans continued to operate. In addition, Toronto Hydro paid its large volume commercial and institutional customers to shift some of their electricity consumption from peak to off-peak periods. As a result of these demand response programs, Toronto's peak day electricity demand in 2006 *declined* relative to 2005. Moreover, in 2006, Toronto bucked a province-wide increase in peak day demand. Specifically, on Ontario's peak demand day (August 1, 2006), while Ontario's province-wide peak demand *increased* by 4% or 845 MW relative to 2005, Toronto's peak demand *fell* by 5 MW.[40]

Unfortunately, the OPA is unwilling to aggressively promote demand response. As a consequence, its proposed demand response programs will not reduce Ontario's peak day demands. Specifically, according to the OPA's forecast, Ontario's peak day demands will increase by 21% by 2025.[41]

To obtain all of Ontario's cost-effective demand response potential, the OPA should pay consumers the same price, to reduce their demands on peak days, that it is willing to pay for peak day electricity supplies.

As **Figure 8** shows, Ontario's electricity consumption per capita is amongst the highest in the world. For example, Ontario's electricity consumption per capita is 60% greater than that of New York State.

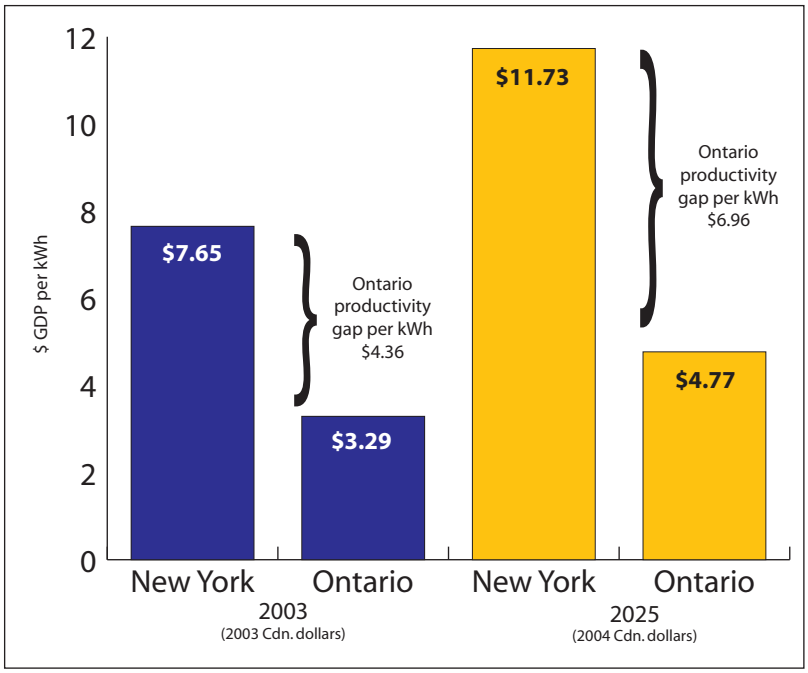
Fig. 8: Electricity consumption per capita[50]



By increasing our electricity productivity (dollars of Gross Domestic Product produced per kWh of electricity consumed), we can simultaneously reduce air pollution and raise our standard of living.

Figure 9 shows Ontario's and New York's actual electricity productivities in 2003 and their projected electricity productivities in 2025.[42]

Fig. 9: Electricity productivity (GDP per kWh)



In 2003, Ontario's electricity productivity gap relative to New York State was $4.36 per kWh (2003 Cdn $) per kWh. If the OPA's proposed electricity plan is implemented, our electricity productivity gap will rise to $6.96 per kWh (2004 Cdn $) in 2025.

The prime reason for Ontario's low electricity productivity is our low electricity prices which discourage the smart and efficient use of electricity. Our low electricity prices, in turn, are due to the following subsidies.

1. Ontario Power Generation (OPG) is not required to earn a competitive rate of return on its electricity generation assets.
2. The Government of Ontario does not require OPG to pay the full market value of the provincial water resources that it uses to produce hydro-electricity.
3. Corporate income tax revenues from OPG, Hydro One and Ontario's municipal electric utilities are used to subsidize the former Ontario Hydro's nuclear debt instead of financing public services (e.g., hospitals, schools).

4. Ontario taxpayers are partially responsible for OPG's and Bruce Power's nuclear reactor decommissioning and long-term nuclear waste storage costs.
5. Taxpayers are responsible for OPG's and Bruce Power's liabilities in excess of $75 million if a nuclear accident occurs.

Unfortunately, the OPA's plan does not include a strategy to eliminate these electricity subsidies and raise the price of electricity up to its full cost in order to increase our electricity productivity and raise our standard of living.

New Renewables

The OPA is required to procure nearly 6,600 MW of new renewable resources by 2025 in addition to those existing and already committed.[43] While the OPA has a standard offer procurement process for renewable electricity projects of 10 MW or less, it currently does not have a procurement process for larger scale renewable resources.

End-Use Fuel Switching

In 2005 electric space and water heating was responsible for 13.5% (21.195 billion kWh) of Ontario's total electricity consumption.[44]

Ontario's space and water heating needs can be met at a lower cost by switching from electricity to renewable energy (e.g., hybrid solar/electric water heaters, geo-thermal heat pumps) and natural gas.

Unfortunately, the OPA's fuel switching targets are modest. Specifically, its fuel switching targets for 2010 and 2025 are only equal to 13% (2.79 billion kWh) and 33% (7.06 billion kWh) of Ontario's electric space and water heating consumption in 2005.[45]

Combined Heat and Power

Ontario's homes, offices and factories typically use natural gas to provide just one service, i.e., heating. It is much more efficient to use natural gas to simultaneously produce two services, namely heat and power. Natural gas combined heat and power (CHP) plants can have an overall energy efficiency of 80 to 90% versus the 30 to 34% energy efficiency of our nuclear and coal-fired power plants respectively.[46]

Ontario can increase its electricity generation productivity and its electricity supply security by converting its schools, recreation centres, condos, shopping malls, office towers and factories into small-scale power plants.

According to a report prepared for the Ontario Ministry of Energy, Ontario's total CHP potential in 2020 is 16,514 MW.[47] However, the OPA's plan proposes to increase our CHP capacity by only 1,089 MW by 2025.[48]

An Alternative Lower Risk and Lower Cost Strategy to Meet Ontario's Electricity Needs

1. The Government of Ontario should issue legally-binding regulations requiring the phase-out of coal burning at the Nanticoke, Lambton, Thunder Bay and Atikokan coal-fired power plants in 2009.
2. The Government of Ontario should direct Ontario Power Generation to convert the Nanticoke and Thunder Bay Generating Stations' boilers from dirty coal to cleaner-burning natural gas.[49]
3. The OPA should pay Ontario's municipal electric utilities, Hydro One and large volume commercial, institutional and industrial consumers a price equal to the full cost of new, clean peak day electricity supplies to shift some of their electricity consumption from peak to off-peak periods on peak demand days.
4. The OPA should develop a strategy to eliminate the subsidies for electricity consumption and to raise the price of electricity up to its full cost.
5. The OPA should establish an annual competitive procurement process to procure renewable electricity projects that are greater than 10 MW in size.
6. Hydro One should rent hybrid solar/electric water heaters and rent or provide on-bill financing for geothermal heat pumps.
7. The OPA should pay Ontario's natural gas utilities and/or Ontario's municipal electric utilities to promote fuel switching from electricity to natural gas for space heating, water heating, cooking and drying. The gas and/or electric utilities should be paid to promote all fuel switching that can meet their customers' needs at a lower cost than electricity.
8. The OPA should establish a standard offer price for small-scale (10 MW or less) combined heat and power (CHP) projects. The standard offer price should be equal to the full cost of new conventional electricity supplies (e.g., nuclear power, natural gas combined-cycle power plants) including transmission capital costs and transmission, distribution and transformer losses. The OPA should enter into contracts with all CHP developers that are willing to accept the standard offer price.
9. The OPA should establish an annual competitive procurement process for CHP projects in excess of 10 MW.
10. The Government of Ontario should exempt CHP projects from the 0.7 cent per kWh nuclear debt retirement charge.
11. Hydro One should not build a new high-voltage transmission line from the Bruce Nuclear Station to the GTA unless the OPA enters into a contract with Bruce Power to re-build the Bruce B nuclear reactors.
12. The aggressive pursuit of demand response, energy efficiency, end-use fuel switching from electricity to renewable energy and natural gas, and new combined heat and power plants in the City of Toronto will eliminate the need for the proposed third transmission line to downtown Toronto.

Nuclear Power

The Ontario Clean Air Alliance does not believe that nuclear power is a cost-effective or low risk option to meet Ontario's incremental electricity supply needs. Nevertheless, if the Government of Ontario believes that nuclear power is a desirable option to meet Ontario's incremental needs, all potential nuclear power projects should be subject to the following market rules.

First, to protect Ontario consumers, the Government should only consider proposals for new or rebuilt nuclear reactors from investor-owned companies.

Second, all proposals for new or rebuilt nuclear reactors must be required to compete on a level playing field with water power (including water power imports from Quebec, Labrador and Manitoba) and natural gas-fired power plants.

Third, nuclear power companies, like gas and renewable power companies, must not be allowed to pass their capital cost overruns on to the OPA or electricity consumers.

Fourth, nuclear power companies, like gas power companies, that fail to achieve their annual capacity utilization targets should be subject to strict financial penalties.

Fifth, nuclear power companies, like renewable and gas power companies, should be 100% responsible for their decommissioning and waste disposal costs and civil liability in the event of an accident.

Endnotes

1 http://www.energy.gov.on.ca/index.cfm?fuseaction=english.electricity. Retrieved January 22, 2007.

2 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 7: Integrating the Elements – A Preliminary Plan*, (November 15, 2006), p. 80, Figure 3.12.

3 According to the OPA's plan, in 2025 Ontario will have 1089 MW of new CHP capacity and the average annual utilization rate of this capacity will be 87%. This entails 8.3 TWh of CHP generation in 2025. According to the OPA's plan, Ontario's total electricity generation in 2025 will be 194 TWh. OPA, *Discussion Paper 7*, pp. 19, 24, 40, 80 & 81.

4 OPA, *Supply Mix Analysis Report*, Volume 2, (December 2006), p. 210; Ontario Ministry of the Environment, *Coal-Fired Electricity Generation In Ontario*, (March 2001), pp. 42, 43; and email from Norman Rubin, Director of Nuclear Research, Energy Probe to Jack Gibbons, August 17, 2004.

5 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 3: Conservation and Demand Mangement Revised,* (December 2006), pp. 89 & 90.

6 OPA, *Supply Mix Advice Report,* Volume 1, (December 2005), p. 50.

7 OPA, *Supply Mix Advice Report,* Volume 1, (December 2005), p. 50.

8 OPA, *Supply Mix Advice Report,* Volume 1, (December 2005), p. 50.

9 OPA, *Discussion Paper 7,* pp. 111, 114 & 115.

10 OPA, *Discussion Paper 7*, p. 111.

11 OPA, *Discussion Paper 7*, p. 114.

12 OPA, *Discussion Paper 7*, pp. 47 & 48.

13 According to the OPA, a key component of its coal phase-out plan is to "Retain plan flexibility and adjust the plan as necessary, based on regular review of risk profiles and new and pertinent information that becomes available." OPA, *Discussion Paper 7*, pp. 50 & 51.

14 OPG, *Sustainable Development 2005 Report,* p. 36; and email to Jack Gibbons from Peter Lafoyiannis, Market Information Services, Independent Electricity System Operator, January 16, 2007.

15 OPA, *Discussion Paper 7,* p. 5, Table 1.1 and p. 49, Figure 2.22.

16 For Ontario's annual electricity consumption from 1960 to 2005, see OPA, *Historical Trends* at http://www.powerauthority.on.ca/ipsp/Storage/26/2129_Ontario_Historical_Energy_and_Peak.pdf; Retrieved January 22, 2007. According to Peter Lafoyiannis, Market Information Services, Independent Electricity System Operator, Ontario's total electricity consumption in 2006 was 151 TWh. According to the OPA's forecast, Ontario's electricity consumption in 2025 will be 189 TWh. See: OPA, *Ontario's Integrated Power System Plan: Supplemental Load Forecast Information,* (December 2006), p. 20.

17 OPA, *Supply Mix Analysis Report,* Volume 2, (December 2006), p. 219.

18 The Darlington Nuclear Generating Station cost $14.3 billion and it has a capacity of 3,524 MW. Letter from Rosemary Watson, Freedom of Information Coordinator, Ontario Power Generation (OPG) to Ravi Mark Singh, Ontario Clean Air Alliance, April 27, 2004; and OPG, *Sustainable Development Report 2004*, p. 41.

19 http://www.econstats.com/weo/CV030V021.htm; Retrieved January 25, 2007.

20 Ontario Energy Board Docket No. H.R. 12, Exhibit No. 7.3.1, June 13, 1983; and letter from R.C. Watson, Freedom of Information Coordinator, OPG to Ravi Mark Singh, Ontario Clean Air Alliance, April 27, 2004.

21 Jake Epp, Peter Barnes & Robin Jeffrey, *Report of the Pickering "A" Review Panel*, (December 2003), pp. 3 & 4.

22 *Report of the Pickering "A" Review Panel*, p. 3; and OPG, *News from Ontario Power Generation*, "Ontario Power Generation Reports 2005 Third Quarter Financial Results", (November 11, 2005).

23 Letter to James Gillis, Ontario Deputy Minister of Energy from CIBC World Markets Inc., October 17, 2005.

24 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 4: Supply Resources*, p. 66.

25 OPA, *Supply Mix Analysis Report*, Volume 2, (December 2005), pp. 180, 238.

26 According to CIBC World Markets, Bruce Power's *nominal after-tax* required rate of return on capital is 10.6 to 13.8%. Moreover, according to the OPA, a *real pre-tax rate* of return of 11% is equivalent to a *nominal after-tax* rate of return on capital of 8%. Letter to James Gillis, Ontario Deputy Minister of Energy from CIBC World Markets Inc., October 17, 2005; and OPA, *Supply Mix Analysis Report*, Volume 2, p. 181.

27 OPA, *Discussion Paper 7*, p. 81.

28 Government of Ontario, *Direction For Change: Charting a Course for Competitive Electricity and Jobs in Ontario*, (November 1997), p. 7.

29 In 2006 Ontario's nuclear reactors produced 84 TWh of electricity. The total capacity of Ontario's nuclear reactors is 13,864 MW. Email from Peter Lafonyiannis, Market Information Services, Independent Electricity System Operator to Jack Gibbons, January 16, 2007; and OPG, *Towards Sustainable Development: 2000 Progress Report*, p. 55.

30 OPG's coal-fired electricity generation rose from 16,669 GWh in 1995 to 36,255 GWh in 2003. Email from Bob Kozopas, OPG to Jack Gibbons, August 22, 2000; and OPG, *Sustainable Development 2005 Report*, p. 36.

31 The August 2003 blackout began on August 14 at 4:11 p.m. Power was totally restored to New York customers by August 15 at 10:45 p.m. Ontario's power emergency did not end until 8 p.m. on August 22. New York Independent System Operator, *Fulfilling Our Mission: 2003 Annual Report*, p. 3; Independent Electricity Market Operator, *Participant News,* "IMO Says Ontario Residents Deserve Special Thanks", (August 22, 2003); and Ontario Ministry of Energy, *August 14, 2003 Outage Report*.

32 OPA, *Supply Mix Analysis Report*, Volume 2, (December 2005), pp. 199, 213, 222 and 226.

33 OPA, *Discussion Paper 7*, p. 84.

34 Email to Amir Shalaby, Vice President, Power System Planning, OPA from Jack Gibbons (March 20, 2006); and email to Jack Gibbons from Mike Agrell, Power System Planning, OPA to Jack Gibbons (March 28, 2006).

35 Displacing a MWh of coal-fired electricity by a MWh of natural gas-fired power will lead to a 730 kg net reduction in greenhouse gas emissions. According to the OPA's *Supply Mix Analysis Report*, p. 238, the cost of natural gas-fired power is $70 per MWh. According to the OPA, the cost of a pulverized coal combustion power plant, assuming an 85% capacity factor and a 11% discount rate, is $67 per MWh. [Email from Amir Shalaby, Vice President, Power System Planning, OPA to Jack Gibbons, July 11, 2006.] Therefore the incremental cost of obtaining the 730 kg emission reduction is $3 ($70 - $67). Thus the cost of obtaining a 1,000 kg (1 tonne) reduction is $4.11 [($3/730 kg) x 1,000 kg].

Displacing a MWh of coal-fired power by a MWh of wind power will lead to a 1,008 kg net reduction in greenhouse gas emissions. The cost of wind power is approximately $86 per MWh. [Ontario Ministry of Energy, *Backgrounder*, "McGuinty Government Announces Nine New Renewable Energy Projects", (November 21, 2005); and email from Rick Jennings, Assistant

Deputy Minister of Energy, Ontario to Jack Gibbons, November 21, 2005.] Therefore the incremental cost of obtaining the 1,008 kg emission reduction is $19 ($86 - $67). Thus the cost of obtaining a 1,000 kg reduction is $18.85 [($19/1008 kg) x 1,000 kg].

Displacing a MWh of coal-fired power by a MWh of nuclear power will lead to a 1,008 kg net reduction in greenhouse gas emissions. Assuming the cost of nuclear power is $97 per kWh, the incremental cost of obtaining the 1,008 kg emission reduction is $30 ($97 - $67). Thus the cost of obtaining a 1,000 kg reduction is $29.76 [($30/1008 kg) x 1,000 kg].

36 Emails from Peter Lafoyiannis, Independent Electricity System Operator to Jack Gibbons, June 20 & 21, 2006.

37 Chief Energy Conservation Officer, OPA, *Annual Report 2006: Ontario – a new era in electricity conservation*, p. 24 and Appendix 1.

38 The cost of an extra kWh of electricity for a Toronto Hydro residential consumer on the summer peak day is 9.7 cents.

39 London Economics International LLC, *Analysis of procurement processes for generation capacity, renewables, demand response, and energy efficiency,* Report prepared for the Ontario Power Authority by London Economics International, (31 August 2005), p. 57.

40 Toronto Hydro, *News Release*, "A Message to All Toronto Hydro Customers and Residents of Toronto", (August 4, 2006).

41 In 2006 Ontario's peak day demand was 27,005 MW. The OPA is forecasting that Ontario's peak day demand in 2025 will be 32,578 MW. OPA, *Ontario's Integrated Power System Plan: Supplemental Load Forecast Information*, (December 2006), p. 20.

42 For the references for our 2003 data please see Ontario Clean Air Alliance, *A New Electricity Strategy for Ontario: Increasing Productivity and Moving Towards a Renewable Future*, (October 2005), p. 61, Table 2. According to the New York State Energy Research and Development Authority (NYSERDA), their draft forecasts for New York's electricity consumption and Gross State Product for 2025 are 198,615 GWh and $1,862.8 billion (2004 US$) [Email from Ted Lawrence, Energy Analysis Program, NYSERDA to Jack Gibbons, January 22, 2007]. According to the OPA, Ontario's forecast electricity consumption in 2025 is 189,244 GWh [OPA, *Ontario's Integrated Power System Plan: Supplemental Load Forecast Information*, (December 2006), p. 20]. Ontario's Gross Provincial Product in 2004 was $517.608 billion (2004 Cdn $) [http://www40.statcan.ca/cbin/fl/cstprintflag.cgi; Retrieved January 22, 2007]. According to the Ontario Ministry of Finance, the province's GDP will rise to $902.0997938 billion in 2025 (2004 Cdn $) [Ontario Ministry of Finance, *Ontario Toward 2025: Assessing Ontario's Long-Term Outlook*, (2005), p. 44]. We have converted New York State's 2025 Gross State Product forecast from 2004 US$ to 2004 Cdn $ using the OECD's purchasing power parity index of 1.25 [http://www.oecd.org/dataoecd/61/56/1876133.xls; Retrieved January 22, 2007].

43 *Discussion Paper 7*, p. 25.

44 Ontario's total electricity consumption in 2005 was 157 billion kWh. For statistics on Ontario's electric space and water heating consumption as a percentage of Ontario's total electricity consumption in 2005 see: Chief Energy Conservation Officer, OPA, *Annual Report 2006: Ontario – a new era in electricity conservation*, p. 24 and Appendix 1.

45 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 3: Conservation and Demand Management Revised*, (December 2006), pp. 29 & 30.

46 OPA, *Supply Mix Analysis Report*, Volume 2, (December 2006), p. 210; Ontario Ministry of the Environment, *Coal-Fired Electricity Generation In Ontario*, (March 2001), pp. 42, 43; and email from Norman Rubin, Director of Nuclear Research, Energy Probe to Jack Gibbons, August 17, 2004.

47 Hagler Bailly Canada, *Potential for Cogeneration in Ontario: Final Report*, (August 2000), p. 25.

48 *Discussion Paper 7*, pp. 19, 24 & 40.

49 For more details about recommendations #1 and 2 see: Ontario Clean Air Alliance, *Phasing Out Coal: 2006 Progress Report*, (November 9, 2006) and *An End to Dirty Power: A real plan to achieve a true coal phase out*, (November 23, 2006).

50 Germany, UK and France: http://devdata.worldbank.org/data-query; In 2000 California's total electricity consumption was 832.7 trillion Btu and its population was 33,871,648 – URL: http://www.eia.doe.gov/emeu/states/sep_sum/html/rank_use_per_cap.html and http://www.census.gov/main/www/cen2000.html; In 2000 New York State's total electricity consumption was 484.6 trillion Btu and its population was 18,976,457 – URL: http://www.eia.doe.gov/emeu/states/sep_sum/html/rank_use_per_cap.html and http://www.census.gov/main/www/cen2000.html; In 2000 Ontario's total electricity consumption was 503.93 PJ and its population was 11,669,340 – National Energy Board, Canada's Energy Future: Scenarios For Supply And Demand To 2025, (2003), Appendix 2, Tables A2.7 and A3.14.

51 OPA, IPSP Stakeholder Consultation, *Discussion Paper #5: Transmission*, Power Point Presentation, (November 22, 2006); and email from Amir Shalaby, Vice President, Power System Planning, OPA to Jack Gibbons, December 5, 2006.

52 OPA, IPSP Stakeholder Consultation, *Discussion Paper #5: Transmission*, Power Point Presentation, (November 22, 2006) and email from Amir Shalaby, Vice President, Power System Planning, OPA to Jack Gibbons, December 5, 2006.

53 OPA, IPSP Stakeholder Consultation, *Discussion Paper #5: Transmission*, Power Point Presentation, (November 22, 2006).

54 OPA, Ontario's Integrated Power System Plan: *Discussion Paper 5: Transmission*, (November 13, 2006), p. 94.

Appendix A: Cost of Supplying Electricity on a Peak Day

According to the Ontario Power Authority, it is assuming that demand response programs will "be in effect during the top 15 summer peak days for six hours per day spanning the peak [90 hours]".[1]

The lowest cost, clean new electricity supply option to meet Ontario's incremental peak day demands is a simple-cycle natural gas-fired power plant.

In this appendix, we will provide a break-out of the cost per kWh of supplying our peak day electricity demands. The costs include:

a) the capital, fuel and operating costs of a simple-cycle natural gas-fired power plant;
b) the capital cost of peaking transmission capacity; and
c) the cost of peak day electricity transmission, distribution and transformer losses.

Simple-Cycle Natural Gas-Fired Power Plant

1. The capital cost of a simple-cycle natural gas-fired power plant is $600 per kW of installed capacity.[2]
2. According to the OPA, to meet a 1 kW increase in peak day demand we need 1.17 kW of incremental generation capacity to provide the system with a 17% capacity reserve margin.[3] Therefore the generation capacity cost of meeting a 1 kW increase in demand is $702 ($600 x 1.17).
3. Amortizing the generation capital cost over 20 years at an 11% cost of capital entails annual capital costs of $88.16. Assuming that this plant is just used to produce electricity for 90 hours of the year (1% of the year), its capital cost is **98.0 cents per kWh.**
4. The OPA is forecasting that natural gas will cost $8 per million BTU.[4] The heat rate of a simple-cycle gas plant is 11,500 BTU/kWh. [9] Therefore the fuel cost of a simple-cycle gas plant is **9.2 cents per kWh.**
5. The fixed operating cost of a simple-cycle gas plant is $17 per kW per year.[5] Assuming this plant is just used for 90 hours per year, its fixed operating cost is **18.9 cents per kWh.**
6. The variable operating costs of a simple-cycle gas plant is **0.3 cents per kWh.**[6]

Transmission Costs

1. According to the OPA, the annual capital cost of 1 kW of incremental transmission capacity is $5.40.[7] However, on peak demand days, up to 22% of electricity produced at a power plant can be lost in the transmission, distribution and transformer systems before it reaches the final consumer.[8] Therefore to meet a 1 kW increase in consumer demand, transmission capacity must be increased by 1.22 kW at a cost of $6.59 per kW of final consumer demand. Assuming that this capacity is just needed to transmit electricity for 90 hours per year, its annual capital cost is **7.3 cents per kWh.**

Transmission, Distribution and Transformer Losses

1. As noted above, the generation fuel and variable operating costs of a simple-cycle gas plant are 9.5 cents per kWh. However, as also noted above, on the peak demand day, up to 22% of the electricity produced at a power plant is lost in the transmission, distribution and transformer systems before it reaches the final consumer. The cost of these peak day losses is **2.09 cents per kWh** (9.5 cents per kWh x 22%).

Summary of Peak Day Electricity Supply Costs

a)	Generation Capital Costs	98 cents per kWh
b)	Generation Fuel Costs	9.2 cents per kWh
c)	Generation Fixed Operating Costs	18.9 cents per kWh
d)	Generation Variable Operating Costs	0.3 cents per kWh
e)	Transmission Costs	7.3 cents per kWh
f)	Transmission, Distribution & Transformer Losses	2.09 cents per kWh
Total		**$1.36 per kWh**

Appendix Endnotes

1 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 3: Conservation and Demand Management Revised*, (December 2006), p. 21.

2 DSS Mangement Consutants Inc. and RWDI Air Inc., *Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation*, Prepared for Ontario Ministry of Energy, (April 2005), p. 9.

3 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 7: Integrating the Elements – A Preliminary Analysis*, p. 17.

4 OPA, *Supply Mix Analysis Report*, Volume 2, (December 2005), p. 238.

5 *Cost Benefit Analysis*, p. 9.

6 *Cost Benefit Analysis*, p. 9.

7 OPA, *Ontario's Integrated Power System Plan: Discussion Paper 7: Integrating the Elements – A Preliminary Plan*, (November 15, 2006), p. 96.

8 Thomas Casten, Chair and CEO, Primary Energy quoted in "Distributed generation should play a much bigger role, expert says", *IPPSO FACTO: Magazine of the Association of Power Producers of Ontario,* (November 2006).

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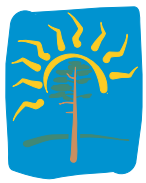

Ontario Clean Air Alliance
625 Church Street, Suite 402
Toronto M4Y 2G1
Tel: (416) 926-1907 ext. 245
Fax: (416) 926-1601
E-mail: contact@cleanairalliance.org
Web Site: www.cleanairalliance.org