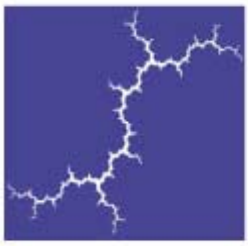

Synapse
Energy Economics, Inc.

# A Clean Path to Ozone Annex Compliance:

## Phasing Out Ontario's Coal-Fired Power Plants

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# THE OntAIRio CAMPAIGN

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# 1. Introduction

The 12 million residents of Ontario share their province with two of the largest coal-fired power plants in North America. The Nanticoke and Lambton power stations, which have 64 years of operation between them, released more than 52,000 tonnes of nitrogen dioxide and over 86,000 tonnes of sulfur dioxide into the atmosphere in 2001. Both sulfur dioxide (SO2) and nitrogen oxides (NOx) contribute to fine particulate matter in Ontario's air, which contributes to approximately 1,900 premature deaths each year. NOx is also a precursor to ground-level ozone, which leads to smog, and both NOx and SO2 are converted to acid aerosols that cause substantial environmental damage when precipitated as acid rain.

The United States and Canadian governments took a significant step in addressing the health impacts of domestic and transboundary air pollution by signing the Ozone Annex in December 2000. The Annex holds the electricity sector in southern Ontario to a 39 kilotonne NOx emissions cap in 2007, representing a 50% reduction from 1998 levels. Compliance with the Ozone Annex will require aggressive reductions in Ontario's coal plant emissions.

Ontario Power Generation, which generates most of the of the electricity that feeds Ontario, recently spent a quarter-billion dollars on "bolt-on," selective catalytic reduction (SCR) emission controls at the Nanticoke and Lambton power plants. While this expensive investment will reduce the quantity of NOx produced at these plants, the reduction will still fall short of the requirements of the Ozone Annex. In addition, SCR technology only addresses a single pollutant, allowing the emissions of other harmful pollutants to continue unchecked.

An alternative to installing stopgap emissions controls on Ontario's dirty coal fleet is to confront the problem at its source. Rather than continue burning coal, Ontario could invest in modern, combined-cycle natural gas plants, which would provide immense public health and environmental benefits relative to their coal burning cousins while enhancing the reliability of Ontario's power system. These gas plants are up to twice as efficient as old coal plants, produce far fewer emissions of NOx and SO2, and release only about a third the amount of carbon dioxide. Replacing Ontario's coal plants would protect the health and environment of Ontario's citizens while mitigating the climate change impact of Canada's energy sector and helping the country meet its carbon reduction commitments pursuant to its recent ratification of the Kyoto Protocol.

At the same time that Ontario phases out its coal plants, the province could reduce emissions even further by investing in combined heat and power, energy conservation, and renewable energy. Combined heat and power (CHP) systems maximize efficiency by providing useful thermal energy in addition to generating electricity. Energy conservation programs are cost effective means of providing emissions savings as well other benefits. And renewable energy technologies can provide electricity while producing zero or relatively minor emissions. Studies suggest that CHP, conservation, and renewables have important roles to play in Ontario's efforts to meet Kyoto targets, and are vital aspects to any long-term clean energy plan.

An economic analysis of a coal phase out scenario indicates that it is a feasible and affordable means to compliance with the Annex. Phasing out the Nanticoke and Lambton power plants and replacing them with efficient natural gas plants by 2007 would add three to five percent to a typical Ontarian household's monthly electricity bill. Furthermore, a plan to implement energy efficiency programs and generate electricity from renewable sources could reduce the costs and increase the benefits of phasing out coal-fired electricity generation in Ontario.

# 2. Ontario's Aging Coal Fleet

Poor air quality is a significant problem in Ontario. According to the Ontario Medical Association (OMA), air pollution results in direct costs to Ontarians of more than $1 billion a year in hospital admissions, emergency room visits, and absenteeism. OMA also estimates that factoring the value of pain and suffering and loss of life into the cost of air pollution would result in total annual economic costs of $10 billion a year. In 2000, air pollution was responsible for an estimated 1,900 premature deaths, a figure that is forecast to rise to 2,600 in 2015 if current levels of pollution are maintained.[1]

Ontario's coal-burning power plants are responsible for 23% of the SO2 and 14% of the NOx emitted in the province.[2] SO2 and NOx both cause respiratory problems in their gaseous forms. They are also converted to airborne sulfates and nitrates, which are fine particulates that can reduce lung function and increase mortality, and are transformed into acidic compounds that contribute to acid rain. NOx is also a precursor to ground-level ozone, which is the main component of smog.

Mercury, a toxic heavy metal that bio-accumulates in the food chain, also exists as a trace element in coal and is released during the generation process. Mercury has been shown to cause developmental and neurological impairment in children. In 1999, Ontario coal plants were responsible for 22% of anthropogenic mercury emissions in the province.[3]

Ontario is home to five coal-burning power plants: Atikokan, Thunder Bay, Lakeview, Lambton, and Nanticoke. Of these, Lakeview, Lambton, and Nanticoke are situated within the boundaries of the Ontario Pollution Emission Management Area (PEMA). The government of Ontario has required that Lakeview cease burning coal by April 30, 2005, leaving Nanticoke and Lambton as the only coal plants in the PEMA region when the Ozone Annex emissions cap takes effect in 2007.

Together, the Nanticoke and Lambton coal plants released over 52 kilotonnes of NO2 in 2001.[4] The 2001 emissions from these two plants alone exceeded the 39 kt Ozone Annex cap by 34 percent. The Nanticoke station, which is the single largest air polluter in Canada, emitted 34 kt of NO2, single-handedly accounting for almost 90% of the cap. Table 1 shows information about the capacity, vintage, generation, and emissions of each plant.

[1] OMA 2000

[2] OMOE 2001

[3] OMOE 2001

[4] OPG 2002

**Table 1. Nanticoke and Lambton Data**

| Plant | Capacity | Original Unit In-Service Date(s) | 2001 Annual Generation (GWh) | NO2 Emission Rate (kg/MWh) | NO2 Annual Emissions |
|---|---|---|---|---|---|
| Nanticoke | 3,920 | 1973-1978 | 21,124 | 1.63 | 34,347 |
| Lambton | 1,974 | 1969-1970 | 10,472 | 1.73 | 18,093 |
| Total | 5,894 | - | 31,596 | 1.66 | 52,440 |

Another concern involving coal plants is their high emissions of carbon dioxide. Coal plants typically release two to three times the amount of carbon dioxide per unit of energy produced compared to those burning natural gas. In 2001, Nanticoke and Lambton combined for almost 30 million tons of CO2 emissions – equivalent to the annual output of more than 5 million cars.[5] Accomplishing the goals set forth in the recently ratified Kyoto Protocol will require significant reductions in the CO2 emissions of Canada's largest fossil fuel power plants. According to one report, a 6 percent reduction in CO2 emissions from 1990 levels would require, among other measures, a decrease of 9,200 GWh of existing coal generation in Ontario.[6]

Ontario's coal plants have also been the subject of recent reliability concerns. According to the Independent Electricity Market Operator's (IMO) monthly Generator Disclosure Report, Nanticoke was supposed to operate at 96 percent capacity in July 2002. Its actual operation, however, was limited to 78 percent. Lambton, which was supposed to operate at 97 percent capacity in the same month, could only deliver at 82 percent.[7] Though it is unclear whether these capacity reductions were the result of environmental regulations or equipment failures, an IMO report suggests that the underperformance of OPG's coal-fired units contributed to short electricity supplies and high prices last summer, when the IMO issued Power Advisory Notices urging electricity users to reduce demand on six occasions.[8]

Ontario Power Generation (OPG), which owns and operates the five coal plants in Ontario, including Nanticoke and Lambton, recently invested a quarter-billion dollars in selective catalytic reduction (SCR) technology at the two of the units at Nanticoke and two at Lambton. SCR is a bolt-on control process that reduces NOx emissions through a catalytic chemical reaction that separates the nitrogen and water in NOx.

[5] A car using the Canadian average of 12 litres/100 kilometres (km) will generate 5,664 kilograms of carbon dioxide a year. http://www.sierraclub.ca/national/climate/climprot.html, accessed 1/24.

[6] NCCP 1999.

[7] IMO 2002.

[8] IMO 2002a.

**Table 2: OPG Emission Control Equipment on Nanticoke and Lambton**

| | SO2 control | NOx control | PM control | CO2 control | Hg control |
|---|---|---|---|---|---|
| Nanticoke (# of units with controls) | None | Low-NOx burners (8); SCR (2)[1] | Low-NOx burners (8) | None | None |
| Lambton (# of units with controls) | Flue gas de-sulphurization (2) | Low-NOx burners (2); SCR (2)[1] | Electrostatic preciptators (4) | None | None |

[1]*SCR installations in progress.*
*Source: EC 2001.*

SCR is typically capable of removing 70 to 80 percent of NOx emissions from the units at which it is installed.[9] However, our analysis shows that OPG's installation of SCR at half of the units at Lambton and one-quarter of the units at Nanticoke will fall short of the reductions required to meet the Annex cap – the same conclusion arrived at by Environment Canada.[10] Even without accounting for the emissions from Ontario's other fossil fuel plants, the NOx emissions from these two coal plants alone may still surpass the Annex cap. Chapter 4 of this report contains a full discussion of these results. Furthermore, SCR is a single-pollutant control technology. Though it is effective in reducing NOx emissions, it does not address SO2, CO2, or mercury. While OPG may use SCR to make some progress towards meeting the Ozone Annex cap, a multi-pollutant strategy that addresses SO2, greenhouse gases, and mercury in addition to NOx is the only long-term solution to the province's air pollution problems and provides the country with some of the necessary carbon reductions to achieve its Kyoto commitments.

Applying bolt-on SCR controls may actually prove counterproductive. OPG's investment in SCR at Nanticoke and Lambton may reflect its intention to extend the useful operating lives of these plants, thereby forestalling the necessary phase-out of dirty coal technology and its replacement with cleaner, more efficient gas-burning units. As long as these obsolete coal plants continue to operate, they will be effectively delaying the construction of modern power plants and the multiple emissions savings they provide.

A wiser course of action may be to phase out Nanticoke and Lambton by 2007 and replace them with clean, efficient natural gas plants. Our analysis suggests that this is an affordable and environmentally preferable means of complying with the Ozone Annex cap. Combined with significant investments in energy conservation and renewable energy technology, such a scenario would provide a sustainable energy future for the province while safeguarding the health of its residents.

[9] USEPA 1998

[10] EC 2001

# 3. A Clean Alternative

Combined cycle natural gas turbines are preferable to steam boilers that utilize coal because of their cleaner emissions, high efficiency, low operating and maintenance costs, and high reliability. For these reasons, most new power plants rely on either natural gas single cycle combustion turbines or combined cycle turbines. The Ontario Independent Electricity Market Operator website indicates that there are several proposals for such plants pending approval.[11]

Combined cycle gas turbines (CCGTs) achieve high efficiencies relative to coal plants by generating electricity from a gas turbine and recovering the exhaust heat to run a steam turbine, thus generating additional electricity from the same amount of fuel. This allows CCGTs to achieve efficiencies up 70 percent higher than conventional coal boilers. Since natural gas is free of sulfur and mercury and is less carbon intensive than coal, it also burns much cleaner.

Table 2 compares the emissions performance of a new, advanced combined cycle gas turbine with SCR to the current emissions of Nanticoke and Lambton.

**Table 2. Comparison of Emissions Rates**

*Emissions in kg/MWh, except for mercury, which is in g/MWh*

| | NOx[1] | SO2 | CO2 | Mercury |
|---|---|---|---|---|
| Nanticoke | 1.63 | 4.09 | 959.10 | 0.014 |
| Lambton | 1.73 | 2.70 | 899.54 | 0.015 |
| New CCGT | 0.04 | 0.01 | 349.27 | 0 |

*[1]emissions are for NOx expressed as NO2. Nanticoke and Lambton emissions are based on OPG's reported emissions in 2001, except for Mercury, which are based on 1999 data from OMOE 2001. Sources: OPG 2002, GE 2000, EPA 1998.*

While any generation process using fossil fuels will result in air pollution, coal plants are far outperformed by their modern, natural gas burning counterparts in terms of emissions, efficiency, and effect on human health. Replacing the 5,894 MW of coal generating capacity that Nanticoke and Lambton possess would require substantial initial investment, but over time, the sustained health and environmental benefits of using cleaner sources of energy could be worth the cost.

CCGTs would also provide reliability improvements over existing coal units. Because they are newer and burn cleaner fuel than coal plants, CCGTs generally have lower outage rates. This is significant in Ontario because the lower-than-expected availability of OPG's coal-fired units, combined with low hydro levels and very high temperatures, nearly resulted in brownouts and blackouts during the summer months of 2002. While Nanticoke and Lambton underperformed by between 15 and 19 percent in July 2002, all

[11] IMO 2003

17 of the IMO-registered natural gas plants were 100 percent available during the times for which they were scheduled.[12] Replacing the coal units at Nanticoke and Lambton with an equal capacity of CCGTs should result in enhanced reliability as well as reduced emissions.

Table 3 provides estimates of some of the cost variables involved in constructing and operating coal plants versus natural gas plants (unless otherwise stated, all costs in this report are in 2002 $CDN). The most uncertain of these is usually the fuel price for natural gas, which tends to fluctuate substantially according to supply constraints and seasonal weather patterns. In the long run, combined cycle natural gas plants are generally cheaper as well as cleaner to operate, but the economic sunk costs of existing coal-burning plants work in favor of extending their lives rather than investing in modern power generating infrastructure.

**Table 3: Coal and Gas Plant Cost Comparison**

| | Capital overnight cost ($/kW) | Fixed Operating and Maintenance cost ($/MW) | Variable Operating and Maintenance cost ($/MWh) | Fuel Cost ($/MWh) |
|---|---|---|---|---|
| Coal-fired boiler | $1795 | $39,463 | $4.95 | $27[1] |
| CCGT | $955 | $16,450 | $3.28 | $33[2] |

*[1] Based on delivered coal price of $54.95/ton, using heat rates for Lambton and Nanticoke.*
*[2] Based on delivered gas price of $4.58/GJ, using heat rate of 7,382 kJ/kWh.*
*Capital and O&M costs based on new plants. Source: EIA 2003.*

The overnight capital cost of a new CCGT in Table 3 includes a number of cost components, including siting costs. The capital cost of building new CCGTs to replace Nanticoke and Lambton could be significantly lower than the figure cited in Table 3 if the CCGTs are built on the same sites as the existing coal-fired units. CCGTs are "off-the-shelf" technologies that have typical lead times of 3 years,[13] meaning that any construction projects initiated by 2004 should be online and operational by the time the Ozone Annex cap comes into effect in 2007.

The volatility of natural gas prices is a significant concern regarding the costs of a coal replacement scenario. Replacing Nanticoke and Lambton with CCGTs would require 235 Petajoules of natural gas per year, or about 6 percent of projected domestic natural gas demand in Canada in 2007.[14] This increase in demand could exert some upward pressure on gas prices, a scenario that is accounted for in our sensitivity analysis. Over-reliance on any single fuel source is a risky energy strategy. As Ontario considers phasing out its heavily polluting coal plants, it can also enhance its energy security and reliability as well as further reduce emissions by making long-term investments in clean energy. Three such sources of cleaner power are described below.

[12] IMO 2002.

[13] EIA 2003.

[14] NRCan 1999. We estimated the 2007 natural gas demand based on a pro-rated average of 2005 and 2010 CEO 99 projections.

## Combined Heat and Power

Combined heat and power (CHP) systems, also known as cogeneration, generate useful thermal energy as well as electricity by capturing the heat that would otherwise be wasted in a conventional generation system and utilizing it to provide steam or process heat. Typically, CHP systems have overall efficiencies of between 65 to 85 percent – compared to typical coal plant efficiencies of roughly 35 percent.[15]

CHP is widely used in industrial applications, and in recent years has been increasingly used in university campuses, commercial buildings, and for district energy. In Canada, CHP accounts for 7 percent of total electricity generation,[16] although it could potentially supply over 20 percent of the country's electricity and thermal needs.[17] The high efficiency of CHP systems, in conjunction with their typical use of natural gas, allows CHP plants to release relatively few emissions per unit of energy they generate. In 1999, the NOx emission rates of CHP plants in the U.S. was on average one-tenth that of average utility grid electricity.[18]

An example of CHP's vast potential to contribute to Ontario's electricity supply is the Portlands Energy Centre (PEC), a proposed 550-megawatt CHP plant that is being developed by a partnership between OPG and TransCanada Energy. The steam output of the plant would be used for district heating in the port area of downtown Toronto. The plant could be operational as early as year-end 2005.

Ontario should provide incentives and reduce market and regulatory barriers to encourage the use of CHP to meet load where there is a need for both thermal energy and electricity. Wherever possible, CHP should be developed as a component of the coal replacement capacity. Using CHP to replace some of the generation of Nanticoke and Lambton could displace even more emissions than replacing the same generation with only CCGTs.

## Energy Conservation

In addition to developing new sources of cleaner power, Ontario should also significantly invest in energy conservation. It is expected that electricity use in Ontario will increase by almost 50 GWh, or 32 percent, in the next 20 years.[19] A well designed, adequately funded energy efficiency program can reduce or even reverse load growth, effectively negating the need for new fossil-fuel power plants and removing thousands of tons of pollutants from the atmosphere while reducing customers' bills. One analysis has suggested that Ontario can easily achieve energy savings of 20,000 GWh over the next decade if systematic efforts are made to capture those savings.[20]

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[15] CIEEDAC 2002

[16] CIEEDAC 2002

[17] Klein 2001

[18] ACEEE 2003

[19] NRCan 1999

[20] CIELAP 2002

An energy conservation program should incorporate a number of cross-sectoral measures, including new appliance standards, product labeling, building retrofits and weatherization, stricter building energy codes, assistance for low-income families, and municipal lighting. Most energy conservation measures are highly cost effective, and the economic benefits of saving energy often outweigh the program costs by a ratio of nearly two to one. Also, numerous studies have suggested that efficiency investments are key to meeting the carbon dioxide emissions target set forth in the Kyoto Protocol.[21]

## Renewable Energy

Renewable energy conversion technologies such as photovoltaic cells and wind turbines can provide zero-emissions electricity without relying on depletable resources. Although generating electricity from these technologies has historically been more expensive than conventional power generation, costs of renewable energy have steadily decreased and are expected to continue becoming more competitive with conventional generation.

The market share of renewable energy in Canada is small but growing, and the untapped potential for renewable energy technologies is substantial. For instance, a National Energy Board report projects that, with favorable levels of renewable technology penetration, Canada will have 3470 MW of wind capacity and 2376 MW of biomass in 2025.

In 1992, a study by the Independent Power Producer's Society of Ontario suggested that the province has the technical potential to develop at least 7,400 MW of wind, small hydro, and biogas capacity, generating over 19,000 GWh per year.[22] This study may understate the technical potential for renewables, since it does not account for the technological improvements that the renewable energy industry has made in the past 10 years. How much of this potential is actually captured will largely depend on continued technological progress and favorable policies. Experience in other countries has demonstrated that renewable energy technologies have flourished when supported by appropriate policy incentives.

[21] For example, see Torrie 2002.

[22] IPPSO 1993.

# 4. Coal Phase Out Scenario

Our analysis examines the costs and emissions savings that would result from phasing out generation from Nanticoke and Lambton and replacing it with generation from advanced combined-cycle gas turbines by 2007. We modeled the following two scenarios:

**Reference case**. This assumes that Nanticoke and Lambton continue producing power indefinitely at levels similar to 1999-2001 generation. This scenario includes the SCR improvements that OPG is in the process of implementing at 2 units at Nanticoke and 2 units at Lambton.

**Gas case.** In this scenario, the 5,894 MW of capacity at Nanticoke and Lambton are replaced with the same capacity of SCR-equipped CCGTs generating an equal amount of electricity.

We also included sensitivity analyses to assess the cost impacts of higher and lower natural gas prices. The main outputs of the phase-out analysis are:

- the NOx, SO2, and CO2 emissions of each scenario
- The levelized cost of electricity generation, which yields the incremental monthly bill impact that the gas scenario would have on an average residential customer.

### Methodology

Our analysis uses a 20-year study period from 2007 to 2027. We used real dollars, a discount rate of 7 percent, and a capital recovery factor of 15 percent. The base year for the cash flow analysis is 2002. Relevant costs that are incurred before 2007, including pollution control and gas plant capital costs, are annualized over the study period.

Between 1999 and 2001, Nanticoke and Lambton operated at capacity factors of 62 and 61 percent, respectively. A possible phase out scenario would be to build less CCGT capacity, assuming that the higher availability of new CCGTs will allow them to run at higher capacities than the coal units they replace. Our model assumes that the CCGTs and coal plants run at the same capacity over the course of the study period. This may overestimate the cost of the phase out scenarios, since operating CCGTs at sub-optimal capacity factors results in relatively high capital costs – the same amount of electricity could be generated from fewer or smaller units than the ones that are constructed in the phase out scenarios. Because the capital cost of natural gas plants is by far the highest cost input in our analysis, taking such a conservative approach has significant impact on the cost differential between the reference and phase out scenario.

The levelized cost of electricity generation is calculated from the cumulative net present value of each scenario. For the reference case, this levelized cost represents the cost of coal generation that could be avoided by phasing out Nanticoke and Lambton. The net cost of the gas scenario relative to the reference case is simply the difference between the levelized cost of gas generation and the avoided cost of coal generation. This difference is then multiplied by the average monthly residential customer's electricity use (assumed to be 860 kWh) to yield the monthly bill impact.

Input data for the analysis was obtained from a variety of sources, including Natural Resources Canada, OPG, the U.S. Energy Information Administration, the U.S. Environmental Protection Agency, the Ontario Ministry of the Environment, and Environment Canada.

## Analysis Results

### Emissions Impacts

Expected emissions from each scenario are presented in Table 5 and Figure 1. In the "business as usual" case, the combined emissions of Nanticoke and Lambton exceed 38 kt of NOx per year, even after OPG's SCR retrofits. These emissions, combined with the emissions of other fossil fuel plants in the Ontario PEMA region, will exceed the 39 kt Ozone Annex cap by a substantial margin.

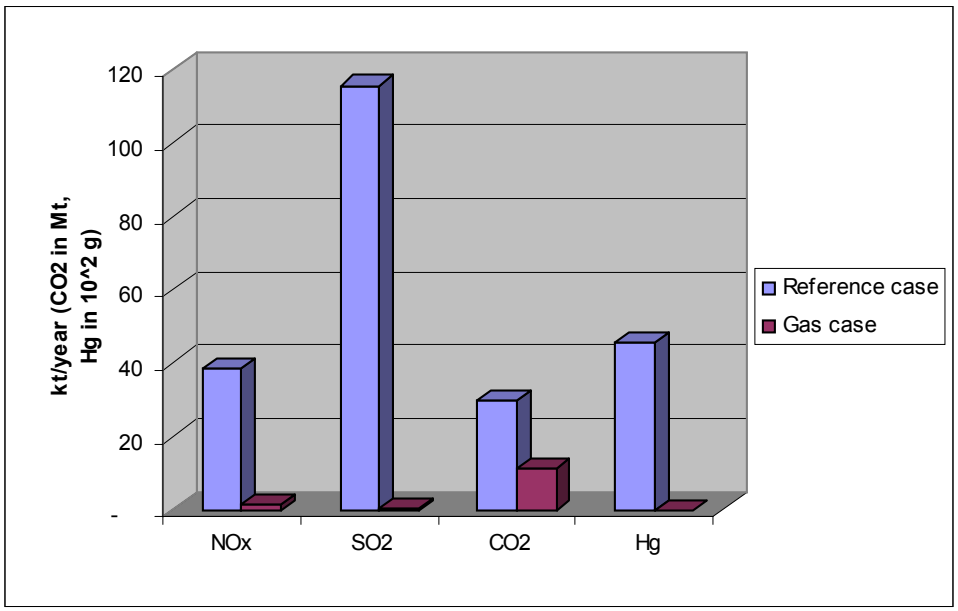
In the phase out scenario, NOx emissions of the replacement CCGTs only amount to 1.2 kt of NOx per year – a 97% reduction from the reference case emissions. Both SO2 and mercury emissions are virtually eliminated, and CO2 emissions fall by almost two-thirds.

**Table 5. Emissions Findings**

| Annual Emissions (2007-2027) in kiltonnes/year (Mercury in kg/year) | | | | |
|---|---|---|---|---|
| | **NOx[1]** | **SO2** | **CO2** | **Mercury** |
| Reference Case | 38.6 | 115.6 | 29,900 | 456.6 |
| Gas Case | 1.2 | 0.3 | 11,100 | 0 |
| Reduction | 37.8 | 115.0 | 18,100 | 456.6 |
| % Reduction | 96.8% | 99.7% | 62.8% | 100% |

[1]*Expressed as NO2.*

**Figure 1. Graphical Comparison of Base Case vs. Gas Case Emissions.**



The 39 kt NOx Ozone Annex cap for southern Ontario was calculated by multiplying projected fossil fuel-based electricity generation in 2007 of 57,601 GWh by a NOx emissions rate of 0.68 kg/MWh.[23] The difference between the generation forecast in 2007 and the generation levels of Nanticoke and Lambton in our analysis is about 26,000 GWh. At the same emissions rate that is used in the Ozone Annex NOx cap calculation, this generation would result in 17.4 kt of NOx emissions. Adding this to the emissions from Nanticoke and Lambton in our reference case scenario results in a total of more than 56 kt of NOx in 2007 – a figure that exceeds the Ozone Annex cap by 44 percent.

By substituting advanced CCGTs with emissions controls for Nanticoke and Lambton, total emissions in southern Ontario would fall to 18.6 kt of NOx in 2007. The total emissions in the gas scenario undercut the Annex cap by 52 percent and are 67 percent lower than total emissions under the reference scenario.

**Table 6. Projected emissions in southern Ontario in 2007.**

| | NOx emissions (kilotonnes) | Change from Ozone Annex cap (kilotonnes) | Percent difference from cap |
|---|---|---|---|
| Reference case | 56.1 | +17.1 | +43.7% |
| Gas case | 18.6 | -20.4 | -52.3% |

While replacing Nanticoke and Lambton with CCGTs would clearly result in dramatic NOx emissions reductions, it is worth underscoring that other harmful pollutants would also be reduced. Both SO2 and mercury negatively affect public health and the environment, and both would be reduced by nearly 100 percent if Nanticoke and Lambton were replaced with advanced CCGTs.

The potential climate change benefits of replacing coal-fired generation are likewise significant. If Ontario were to reduce its greenhouse gas emissions in proportion to the national targets of the Kyoto Protocol, the province would need to reduce its CO2 emissions by about 42 million tons from 2010 business-as-usual levels.[24] Under the gas replacement scenario, CO2 emissions would fall by 18.8 million tons, which represents about 46 percent of Ontario's share of the Canada's required Kyoto reductions.

### Financial Impacts

The capital cost of building 5,894 MW of new CCGTs is reflected in higher levelized costs of electricity generation in the gas scenario, as shown in Table 7. These costs are based on a number of financial and technical assumptions and should be seen as reasonable estimates of the costs of coal and gas generation. Perhaps the most uncertain variable in calculating the financial impacts of the phase out scenario is the future price of natural gas. Natural gas prices have demonstrated considerable volatility in recent

[23] This emissions rate is based on the U.S. emissions performance rate of 0.15 lb/MMBtu on a heat input basis, assuming heat rates representative of Ontario's coal-fired power plants. Source: EC 2001.

[24] NRCan's projected CO2 emissions for Ontario in 2010 are 213 megatonnes, or 41.92 megatonnes more than 94% of 1990 emissions. NRCan 99.

years, which makes it difficult to accurately forecast the path of future prices. The sensitivity analyses for the gas scenario serve to illustrate the potential range of cost impacts resulting from lower and upper bounds of projected natural gas prices.

**Table 7. Financial Impacts of Coal Phase Out[25]**

| | Levelized cost of generation (cents/kWh) | Incremental cost per residential consumer (cents/kWh)[1] | Monthly residential bill impact in 2007 | % increase in monthly bill[1,2] |
|---|---|---|---|---|
| Reference case | 4.40 | - | - | - |
| Gas case | 6.96 | 0.49 | $4.19 | 4.32% |
| Gase case – low gas price | 6.42 | 0.38 | $3.30 | 3.42% |
| Gase case – high gas price | 7.61 | 0.61 | $5.25 | 5.42% |

*[1]Based on average monthly residential consumption of 860 kWh.*
*[2]Based on electricity cost of 9.64 cents/kWh, which was the average residential price between 5/1/02 and 3/19/03.[26]*

Our analysis suggests that the costs of phasing out coal generation at Nanticoke and Lambton would add 3.4 to 5.4 percent to the average residential customer's monthly electricity bill. While these costs are not insignificant, they do not appear unreasonable when placed in the perspective of other electricity charges. For example, since 2001, each residential electricity customer in Ontario has been assessed a debt retirement charge of 0.7 cents for each kWh of electricity that he or she consumes.[27] This surcharge was introduced to pay down the residual stranded debt of the former Ontario Hydro. According to our analysis, phasing out Nanticoke and Lambton will add between 0.38 and 0.61 cents per kWh to Ontarian residents' cost of electricity – considerably less than the price they currently pay to recover Ontario Hydro's stranded debt.

Energy conservation programs have the potential to mitigate the cost impact of phasing out Nanticoke and Lambton. By reducing their energy consumption, Ontarians will save on their electricity bills while helping to further reduce emissions from fossil fuel-based generation. In addition, the phase out costs in our analysis may be overstated if OPG elects to spend more money on bolt-on emissions controls in an effort to meet the Annex cap or other air quality legislation. Bridging the 17.4 kt gap between projected NOx emissions in 2007 and the 39 kt Annex cap through emissions controls would require OPG to incur significant costs on top of the quarter-billion dollars it has already

[26] The Electricity Pricing, Conservation, and Supply Act of 2002 froze commodity electricity prices at 4.3 cents per kWh on December 9, 2002. Because this is a temporary measure designed to ease the province's transition into a deregulated electricity market, we chose to use the cumulative weighted average of the hourly Ontario electricity price, which is more representative of actual generation costs. Source: Energyshop.com 2003.

[27] OEB 2002

committed to SCR retrofits. Since bolt-on NOx controls to OPG's existing fossil fleet would ignore the emissions of other pollutants such as SO2 and mercury and fail to contribute to the CO2 reductions that are required by the Kyoto Protocol, such a course of action would be highly unfavorable to Ontario's public health and environment.

There is also a possibility that OPG may be allowed to meet its Annex requirements through Ontario's NOx Emissions Trading Regulation. At the present time, the government of Ontario has not clearly indicated whether emission reduction credits obtained through a NOx trading program could be counted against the Annex cap. While a NOx trading program can be an efficient and effective means of regulating air quality, Ontario's trading system appears to contain significant flaws. By allowing trading with uncapped sectors, the system does not provide any guarantee that total emissions in the province will decline. If an emissions credit and trading program is allowed to interact with the Ozone Annex, the trading regime must be structured to ensure that the electricity sector cap of 39 kt NO2 is not enlarged.

# 5. Conclusion

Phasing out coal-fired generation at Nanticoke and Lambton is an environmentally sound and economically feasible way for Ontario to meet the Ozone Annex cap. Compared to the reference case, substituting advanced combined cycle natural gas turbines for Nanticoke and Lambton's coal units will reduce NOx emissions from those plants by 97 percent and will reduce total NOx emissions in the southern Ontario PEMA region by 67 percent. With the coal plants retired, regional NOx emissions in 2007 will comprise less than half of the Annex cap – and emissions of SO2, CO2, and mercury will also be dramatically reduced compared to business-as-usual levels.

Ontario can attain these emissions reductions and their corresponding benefits to the province's public health and environment for a reasonable cost. The phase out scenario will add between three to five dollars, or about three to five percent, to the average residential customer's monthly electricity bill. These costs, while affordable, would be lower if the avoided cost of coal-fired generation at Nanticoke and Lambton were to include additional pollution control measures that OPG may undertake to comply with the Annex in recognition of the likelihood that its currently planned SCR installations will prove insufficient.

Generating electric power from aging coal-fired power plants also generates a number of negative externalities. The true cost of electricity generation should account for the billions of dollars of health care costs and environmental damage that result from the air pollution produced by burning fossil fuels for energy. Because it does not, the costs of generating electricity from Nanticoke and Lambton as calculated in our analysis are deceptively low. Accounting for the external costs of coal-fired generation would substantially lower the incremental cost of replacing Nanticoke and Lambton with CCGTs.

Although producing power from any conversion technology that utilizes fossil fuel will result in negative externalities, using CCGTs in place of coal-fired boilers mitigates the environmental and health impacts of generating electricity. To further reduce these impacts, the government should approve legislation that removes regulatory barriers to combined heat and power and effectively encourages energy conservation and renewable energy. Adopting a renewable portfolio standard (RPS) would require the province to obtain a minimum percentage of its electricity from low-impact renewable resources. An RPS is a market-based approach to stimulating investment in renewables that typically requires an increasing percentage of renewable power over a five-to-twenty year timeframe. The government could also establish a renewable energy fund to provide financial support for promising new projects. Aggressive policies to encourage renewable energy can drive down the cost of technology to levels that are more competitive with conventional sources of electricity.

Ontario should also invest in energy efficiency programs. Demand Side Management (DSM) programs can reduce peak demand and overall load by a significant margin, and over the course of multiple years can reduce or even eliminate the need for new fossil fuel-based plants. Unfortunately, the profit structures of most electric distribution companies are tied to how much electricity they sell, giving them little incentive to

implement DSM programs that would reduce their revenues. The government should remove these conservation disincentives and replace then with shared-savings mechanisms that encourage aggressive energy conservation programs.

The analysis in this report calculates the costs and benefits of replacing Nanticoke and Lambton with CCGTs based on a number of simplified assumptions. A broader, more comprehensive study of the entire Ontario power system that relies on full simulation modeling could provide more detailed and accurate results. A province-wide system study could also incorporate a medley of coal replacement resources such as CHP, energy conservation, and renewables in addition to natural gas and quantify the reliability effects of a coal phase-out scenario. A broader study could also include a survey of Ontarians' willingness to pay for the public benefits of such a scenario. While the numeric outputs of such a study would differ somewhat from those of this report, the same conclusion should hold true: Removing Ontario's coal plants and replacing them with cleaner, more reliable sources of generation will result in tremendous emissions savings across a range of pollutants for a reasonable cost.

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# Appendix A: Explanation of Inputs

| Financial Assumptions | | Source |
|---|---|---|
| Discount rate | 7% | Cheminfo 2001, see note 1 |
| Discount year | 2002 | |
| Annualization rate | 15% | See note 2 |
| U.S. – Canada Exchange rate | 1.57 | Bank of Canada 2002 |

| | Base (coal) case | Gas case | Source |
|---|---|---|---|
| **Technical Assumptions** | | | |
| Heat rate | 10,183 kJ/kWh[a]<br>10,070 kJ/kWh[b] | 7,382 kJ/kWh | OMOE 2001 (base case); EIA 2003 (gas case) |
| Energy content factor | 22.20 GJ/tonne | 1.05 GJ/mcf | NRCan 1999 |
| **Fuel Price Assumptions** | | | |
| Delivered fuel price in 2007 | $54.95/tonne | $4.58/GJ<br>$3.89/GJ (low)<br>$5.95/GJ (high) | See note 3 |
| Average annual escalation rate | 0% | 1.8% (medium and low)<br>0.5% (high) | NRCan 1999; see note 4 |
| **Capital and O&M Cost Assumptions** | | | |
| Fixed non-fuel O&M | $39,463/MW/year | $16,450/MW/year | EIA 2003 |
| Variable non-fuel O&M | $4.95/MWh | $3.28/MWh | EIA 2003 |
| Overnight capital cost | - | $955/kW | EIA 2003 |
| Plant life extension cost | $200/kW | - | See note 5 |
| **Pollution Control Cost Assumptions** | | | |
| Capital cost of SCR | $123.77/kW | $35.15/kW | EPA 1997 |
| SCR fixed O&M | $11.00/kW-yr | $1.50/kW-yr | EPA 1997 |
| SCR variable O&M | $6.90/MWh | $1.72/MWh | EPA 1997 |
| **Emission Coefficients** | | | |
| NOx | 1.63 kg/MWh[a]<br>1.73 kg/MWh[b] | 0.04 kg/MWh | OPG 2002 (base case); GE 2000 |
| SO2 | 4.09 kg/MWh[a]<br>2.70 kg/MWh[b] | 0.01 kg/MWh | OPG 2002 (base case); EPA 2000 |
| CO2 | 959.10 kg/MWh[a]<br>899.54 kg/MWh[b] | 349.27 kg/MWh | OPG 2002 (base case); EPA 2000 |
| Mercury | 0.014 g/MWh[a]<br>0.015 g/MWh[b] | 0 | OMOE 2001 |

*All Costs in 2002 dollars.*

[a] *Value for Nanticoke*

[b] *Value for Lambton*

Notes:

1. Cheminfo uses the same discount rate in its analysis of multi-pollutant emissions reductions for Environment Canada.

2. EIA's National Energy Modeling System uses a capital recovery factor of 15.9% for CCGTs. We have applied a 15% annualization rate to all capital investments in our analysis.

3. Our delivered fuel prices are composites of various price forecasts from different sources, including Natural Resources Canada, Cheminfo, NYMEX, and the National Energy Board. The starting 2007 price in the low gas price case is 15% lower than the base case price, and the high price is 25% higher than the base case price.

4. Most forecasts predict close to zero real growth in future coal prices. The average growth rate of 1.8% for natural gas is based on NRCan's forecast for gas prices between 2005 and 2020. In the high gas price scenario, we use a lower escalation rate of 0.5% because we assume that short-term high gas prices will normalize in the long-term. Similar trends are evident in NYMEX futures prices.

5. Cheminfo estimates that coal/oil units incur substantial life extension maintenance costs 40 to 50 years after start-up, at costs ranging from $130 to $500/kW (in 2000 dollars). For Nanticoke and Lambton, this life extension maintenance is expected to occur between 2010 and 2020.

# Appendix B: Summary of Analysis Results

**Table 1. Financial Cost and Emissions Summary**

| | | Average Annual Results, 2007-2027 | | | |
|---|---|---|---|---|---|
| | **Unit** | **Reference Case** | **Gas Replace-ment** | **Gas Replace-ment – Low Gas price** | **Gas Replace-ment – High Gas Price** |
| **Generation** | GWh | 31,856 | 31,856 | 31,856 | 31,856 |
| **Capacity Factor** | | 0.62 | 0.62 | 0.62 | 0.62 |
| **Capital Cost** | $million | $0 | $844 | $844 | $844 |
| **Fuel Use** | Petajoule | 323 | 235 | 235 | 235 |
| **Fuel Price** | $/GJ | $2.48 | $5.41 | $4.60 | $6.25 |
| **Fuel Cost** | $million | $915 | $1,281 | $1,089 | $1,472 |
| **Fixed O&M Cost** | $million | $233 | $97 | $97 | $97 |
| **Variable O&M Cost** | $million | $158 | $105 | $105 | $105 |
| **Life Extension Cost** | $million | $177 | $0 | $0 | $0 |
| **SCR Capital Cost** | $million | $37 | $31 | $31 | $31 |
| **SCR Fixed O&M Cost** | $million | $22 | $9 | $9 | $9 |
| **SCR Variable O&M Cost** | $million | $73 | $55 | $55 | $55 |
| **Total Annual Cost** | $million | $1,498 | $2,422 | $2,230 | $2,612 |
| **NO2 Emissions** | kilotonnes | 38.6 | 1.2 | 1.2 | 1.2 |
| **SO2 Emissions** | kilotonnes | 115.6 | 0.3 | 0.3 | 0.3 |
| **CO2 Emissions** | kilotonnes | 29.9 | 11.1 | 11.1 | 11.1 |

*All costs in 2002 constant dollars.*

**Table 2. Financial Impacts**

| | **2007** | **2012** | **2017** | **2022** | **2027** |
|---|---|---|---|---|---|
| **Monthly Residential Bill Impact** | | | | | |
| Gas Replacement | $4.19 | $3.93 | $3.66 | $3.40 | $3.16 |
| Gas Replacement – Low | $3.30 | $3.10 | $2.88 | $2.68 | $2.50 |
| Gas Replacement - High | $5.25 | $4.93 | $4.58 | $4.26 | $3.97 |
| **Incremental Cost (cents/kWh)** | | | | | |
| Gas Replacement | 0.49 | 0.46 | 0.43 | 0.40 | 0.37 |
| Gas Replacement – Low | 0.38 | 0.37 | 0.34 | 0.31 | 0.29 |
| Gas Replacement - High | 0.61 | 0.57 | 0.53 | 0.50 | 0.46 |
| **Percent Increase in Residential Bill** | | | | | |
| Gas Replacement | 4.3% | 4.1% | 3.8% | 3.5% | 3.3% |
| Gas Replacement – Low | 3.4% | 3.2% | 3.0% | 2.8% | 2.6% |
| Gas Replacement – High | 5.4% | 5.1% | 4.7% | 4.4% | 4.1% |

*All costs in 2002 constant dollars.*