Will Free Trade in Electricity between Ontario/Canada and the U.S. Improve Environmental Quality?

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Executive Summary

Ontario and the eastern United States share a common airshed and heavily interconnected electricity systems. In addition, the electricity generation mix is very different in Canada and the United States, resulting in significantly different air emission profiles. Studies have shown that US emissions sources have a significantly larger impact on Canadian air quality than Canadian emission sources do on the United States. As a result, any change in coal-fired electricity generation in the United States could affect the air quality in Canada.

Both countries have made significant reductions in emissions and regulatory trends indicate that further reductions will be required in the near future. With the opening of electricity markets in both countries, environmental regulatory policies will influence the flow of electricity across the borders.

The impact of NAFTA on trade in electricity is difficult to quantify. The trade of electricity between Canada, Ontario, in particular, and the United States has been very volatile over the last decade. Two major factors have determined the size of electricity trade with the United States at various times: limited excess supply of power for exports from Canada and limited access to the electricity markets in both countries, since utilities continued to be regulated.

Based on the results of this study, the impact of free trade in electricity between Ontario and the United States is not expected to affect the air quality in Ontario if both countries follow through with their plans to implement tighter NO_x emission standards (NO_x SIP Call). In the short-run, however, if open access takes place before the SIP Call comes into effect, the emissions could increase—adversely affecting the air quality in Canada and the United States.

Based on the analysis above, the following policy considerations are proposed:

- The environmental regulations should take into consideration differences and potential impacts of air emissions between the two countries.

- The regulatory systems in Canada and the United States should continue to converge by harmonizing air emissions standards. This would help ensure that electricity generators compete on a level playing field as the electricity markets open to competition.

- The emissions trading programs should be harmonized in order that the generators in both countries are able to take advantage of opportunities for cost-effective emissions reductions.

- The two countries should establish a process for harmonizing the development of new environmental regulations, such as those concerning mercury emissions and long-

term targets for SO_2 and NO_x emission reductions, as they address the issue of PM_{10} and $PM_{2.5}$ particulates in the coming years.

The definition of environmental provisions (i.e., renewable portfolio standards or emission portfolio standards) proposed to enhance cleaner technologies need to be harmonized to ensure a level playing field in the electricity markets.

1. Introduction

Significant changes are taking place in the electricity industry around the world and particularly in North America. Following the deregulation in the telecommunications, transportation and natural gas industries over the last two decades, the electricity industry in North America is in the middle of massive restructuring. This is the result of many factors including globalization of trade, technological developments in electricity generation and pressure from large industrial customers to have the flexibility to choose their own supplier of electricity in order to reduce their electricity costs.

The deregulation of the electricity industry in Canada and US and the competition in the wholesale and retail electricity markets that is gradually taking place will introduce new dynamics in the electricity trade between the two countries. The electricity trade between Ontario and the neighboring states in particular is expected to increase emphasizing regional competition and de-emphasizing the importance of the borders.

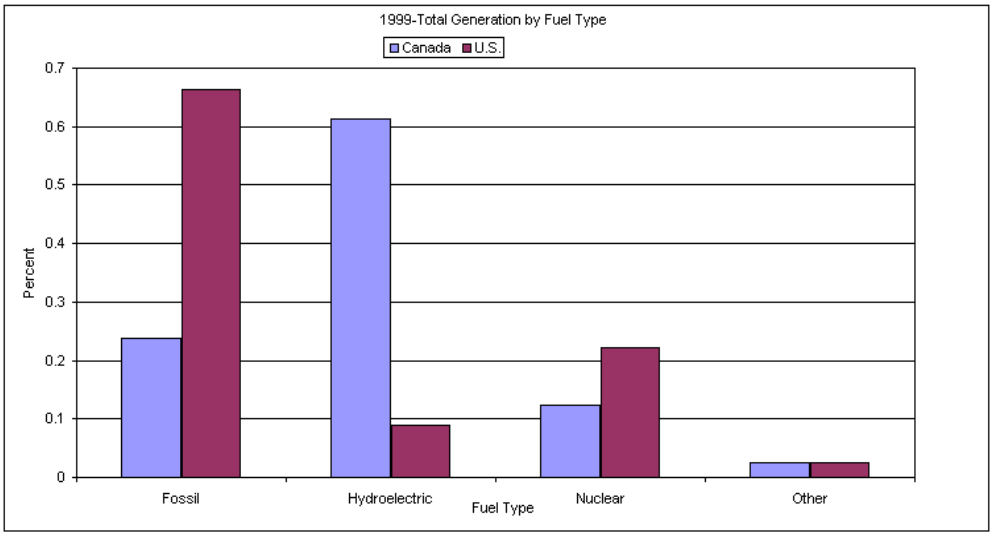
This report begins with a comparison of the electricity generation profile of Canada and US followed by an assessment of the transboundary impacts of air emissions. Then it focuses mainly on two of the four processes identified in the NAFTA evaluation framework proposed by CEC. First, the current and future use of coal for electricity generation and the associated emissions under competitive market conditions that could affect the environment is assessed. Second, the impact of existing and emerging environmental regulations on coal generation and the competitive position of electric utilities are discussed. Finally the impact of these changes on the electricity trade between Ontario and its neighboring regions is assessed. The paper concludes with a summary of major findings and policy considerations to minimize the impact of electricity trade on the air quality of both countries.

2. Electricity Generation Profile of US and Canada

In order to examine the potential impact of electricity free trade on air quality, it is necessary to study the electricity generation profile of the two countries and the regions neighboring to the province of Ontario in particular.

As shown in Figure 1, 66% of electricity in US is produced from fossil fuels with coal and oil accounting for 57% of generation.

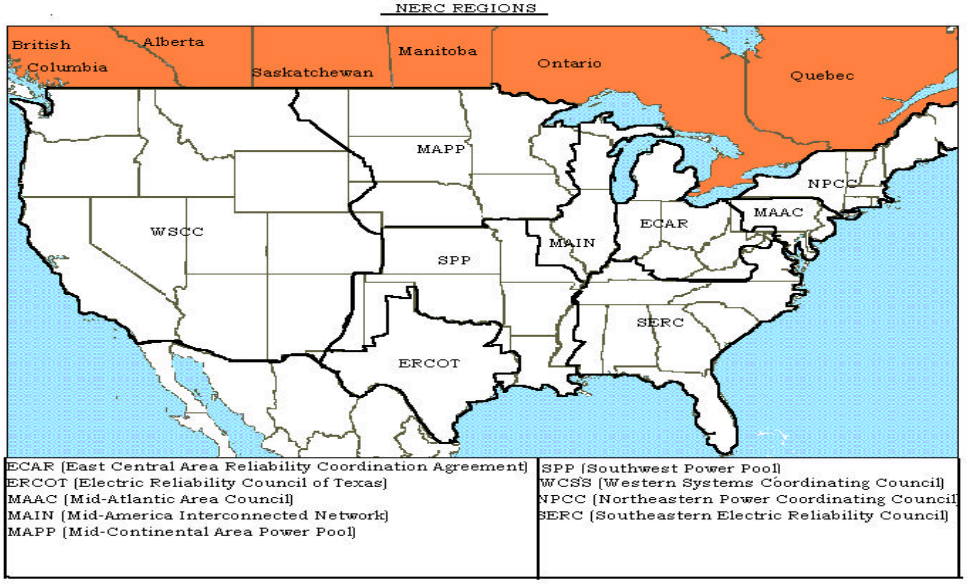
Figure 1



The electricity generation profile of Canada is quite the opposite. Only 24% of generation is produced by fossil fuels. The remaining is hydroelectric and nuclear generation, which do not emit any SO2, NOx or CO2 emissions.

The contribution of coal to electricity generation in US varies significantly by region. Figure 2 below shows the different regions as defined by the North American Electric Reliability Council (NERC). Ontario has high capacity interconnections with the East Central Area Reliability (ECAR) region and the Northeast Power Coordinating Council (NPCC) on the South and smaller capacity interconnection with Mid-continent Area Power Pool (MAPP) on the North.

Figure 2



The generation profiles of the two most important regions, NPCC and ECAR are discussed below and compared with Ontario. The electricity generation profile of the two regions is quite different.

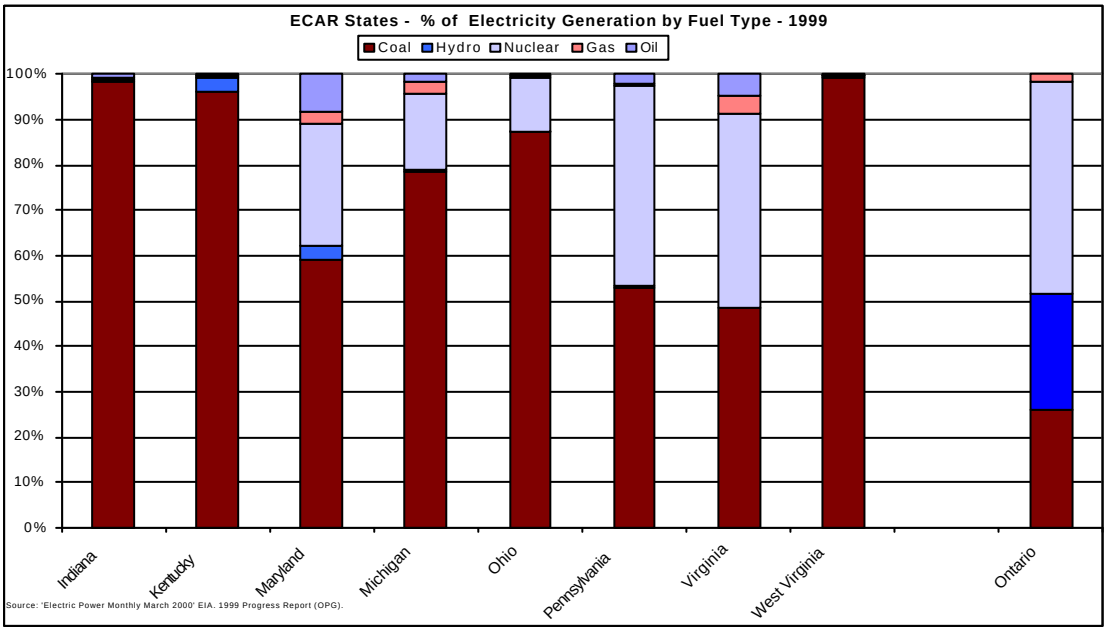
ECAR region is dominated by coal, which accounts for more than 80% of its electricity generation. Coal is cost effective as the mid-western coal producing states are located near or within the coal fields of the Illinois Basin and Northern Appalachia, which lowers the cost of fuel transportation.

NPCC has markedly different generation assets with coal contributing less than 16% of its electricity with the remaining provided by nuclear, hydroelectric, oil and gas generation. This is because coal is relatively expensive in NPCC region due to higher transportation rates for both low and higher sulfur coals.

Ontario's electricity generation is also different when compared to ECAR and NPCC regions. Ontario Power Generation (OPG) with total capacity of 31,000 MW supplies close to 90% of electricity in Ontario. About 50% of electricity generation comes from nuclear power. Ontario's generation is dominated by nuclear, since the province made a strategic decision in early seventies to invest in nuclear power given that it does not have endogenous coal or gas resources. Another 25% of electricity is produced from renewable hydroelectric sources, which produce virtually no air emissions. The remaining 25% of electricity is generated mainly by coal and natural gas.

Coal generation in the ECAR states accounts for close to 45% of the total coal generation in US. Figure 3 shows the share of fuels used for electricity generation in the states within the ECAR region.

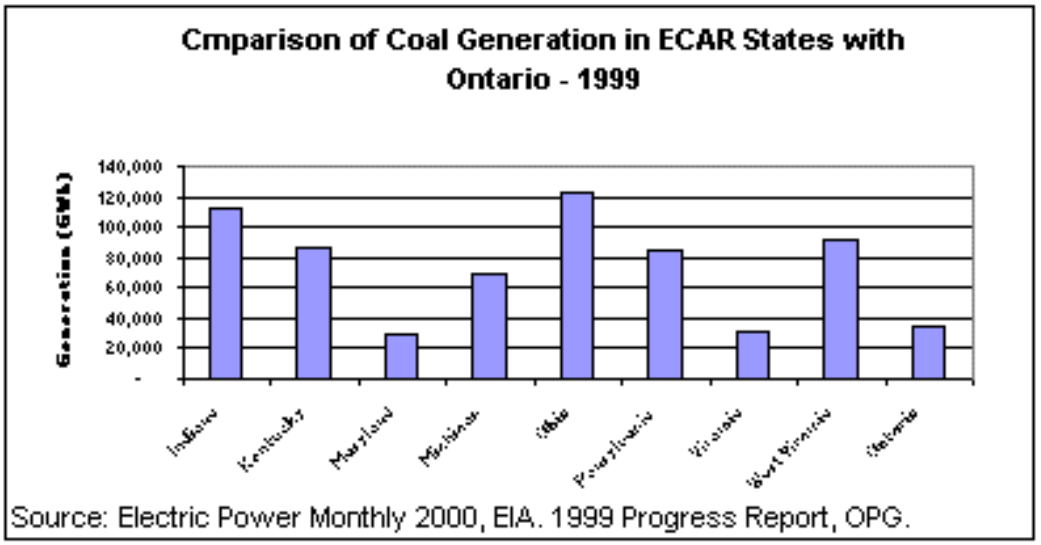
Figure 3



It is interesting to note that in 1999 coal accounted for close to 100% of generation in both states of Indiana and West Virginia and for 95% of total generation in Kentucky. Pennsylvania and Virginia have the lowest share of coal generation, which accounts for about 60% of total generation.

Figure 4 compares coal-fired generation levels in the ECAR states with Ontario. With the exception of Maryland and Virginia where their coal generation is at similar levels to Ontario's, the coal generation in each of the remaining ECAR states is two to three times larger than Ontario's.

Figure 4



The analysis above suggests that any significant increase in electricity exports from the ECAR neighboring states will be based on coal and will impact on air quality in Canada and US. The amount of electricity exports from the ECAR region to Ontario will depend on many factors including the environmental regulations in the two countries, the degree of deregulation of electricity generation and transmission and the differences in electricity prices between the two regions. These factors are addressed in more detail later on in the report.

3. Electricity Trade between Canada and US

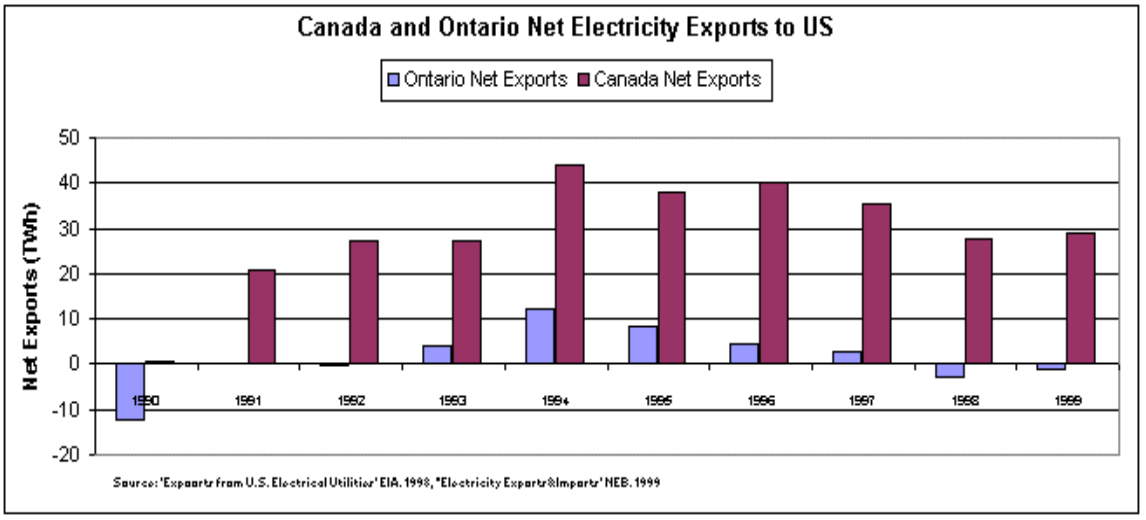
The capacity of Ontario's interconnections with the ECAR and NPCC in the South is 2100-2400 MW and 1700-1750 MW respectively while with MAPP in the North is much smaller ranging from 100 to150 MW.

Traditionally trade between Canada and US is very much a north-south activity based mainly on regional economics. This is because the natural resources in Canada, primarily

those that are hydroelectric and nuclear, tend to have lower cost than the cost of generation in the US. As a result, the stronger transmission lines and US interties have been developed with Quebec, Ontario, Manitoba, BC and Saskatchewan. Alberta market does not have a direct north-south intertie into the US.

Figure 5 shows the net electricity exports (exports minus imports) of electricity to US. Historically the province of Ontario and Canada in general has been a significant electricity exporter into the US market. The electricity exports from Canada to US have been quite volatile over the last 20 years reflecting mainly the availability of generation in Canada. The electricity exports peaked in 1987 and 1994 at approximately 50 TWh (or 44 TWh net). The Canadian exports using coal accounted for less than 20% of total exports. This has contributed over the years to US significantly reducing its fossil emissions. The imports from the US on the other hand tend to be dominated by coal generation.

Figure 5



Ontario exports over the last 20 years peaked in 1994 at 12.6 TWh. Since then, electricity exports have constantly declined reaching 2.02 TWh in 1999. The electricity imports from US have increased recently to 6.05 TWh and 3.04 TWh in 1998 and 1999 respectively making Ontario a net importer of electricity. This is because Ontario has shut down two of its nuclear stations since 1997. As the nuclear recovery program proceeds over the next few years, Ontario is expected to reestablish itself as a net exporter of electricity into the US.

Although there was an increase in electricity net exports in 1990's, it is difficult to attribute any significant changes in electricity trade to NAFTA. Two major factors have determined the electricity exports over this period: limited excess supply of power in Canada for exports and limited access to the electricity markets in both countries since utilities were regulated.

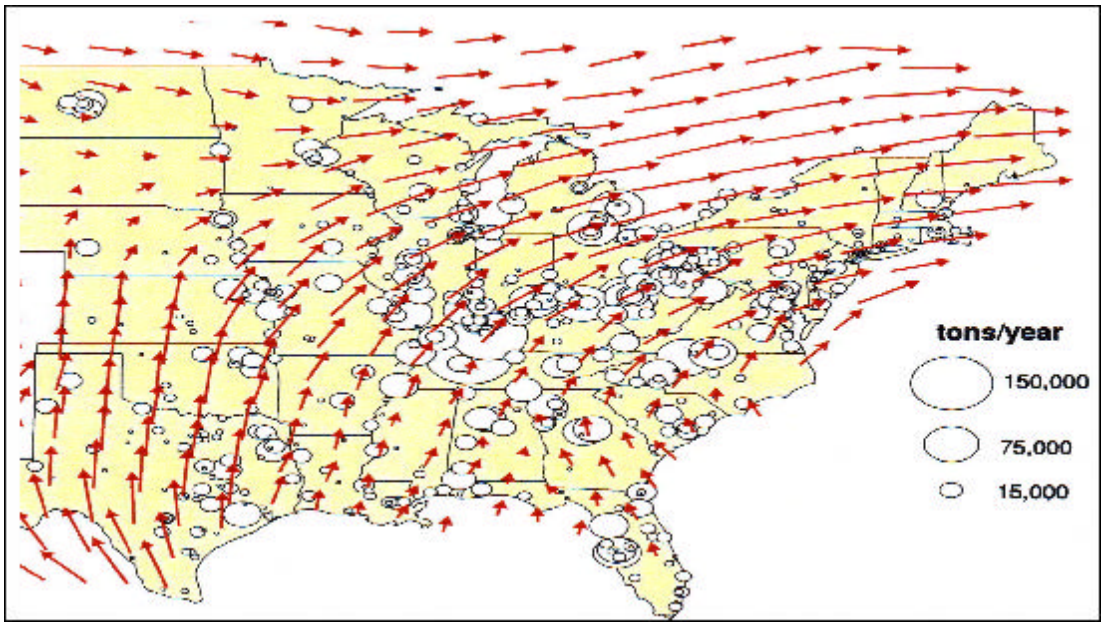
4. Transboundary Air Pollution Associated with Coal-fired Generation

Sulphur Dioxide (SO_2) and Nitrogen Oxide compounds (NOx) are emitted through the burning of fossil fuels. These compounds, once released into the atmosphere, combine with other chemicals to form acid rain and ozone respectively. The acid rain effects lakes and forests while ozone, known as smog, is a significant health hazard. The CO2 has global impacts, as it is associated more with climate change.

Air emissions do not only affect the immediate surrounding area in which they are produced. Rather, they are transboundary in nature and are carried by prevailing winds, affecting an entire airshed. The map in Figure 6 shows the prevailing wind patterns across Eastern North America.

Figure 6

Eastern North American Prevailing Wind Pattern and Sources of NOx

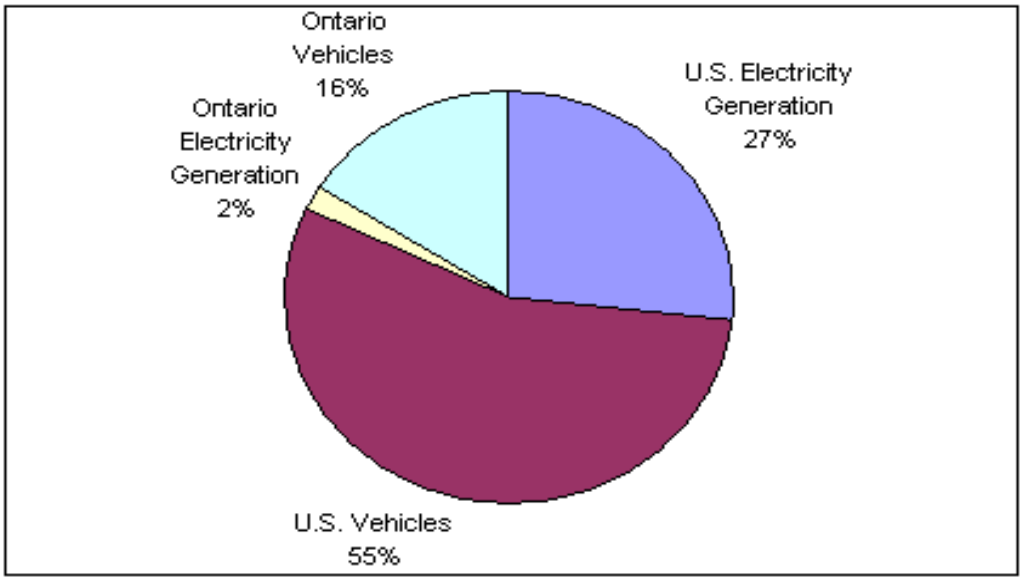


Winds travel from the Gulf of Mexico in a circular, northeastern direction. In this fashion, air emissions are carried from the central and north-central states into Ontario, Quebec and Nova Scotia in Canada and Northeast states in US. The distance of transportation is dependent on the altitude of the emissions. Low-level emissions (primarily from vehicle emissions) travel a shorter distance than high-level emissions (primarily from fossil fuel generated electricity). Industrial, commercial and transportation emitters both inside and outside of the province contribute to the smog problem in southern Ontario. The Ontario government has estimated that 50% of the average annual ozone formation in Ontario is attributed to US sources.

Research co-sponsored by Environment Canada, OPG and Hydro-Quebec, indicates that, during high smog conditions, 55% of Southern Ontario's ozone is a result of vehicle emissions in the U.S. Another 27% is the result of U.S. electricity production and 16% is from Ontario vehicle emissions. Only 2% of Southern Ontario's ozone is the result of electricity production in Ontario.

Figure 7

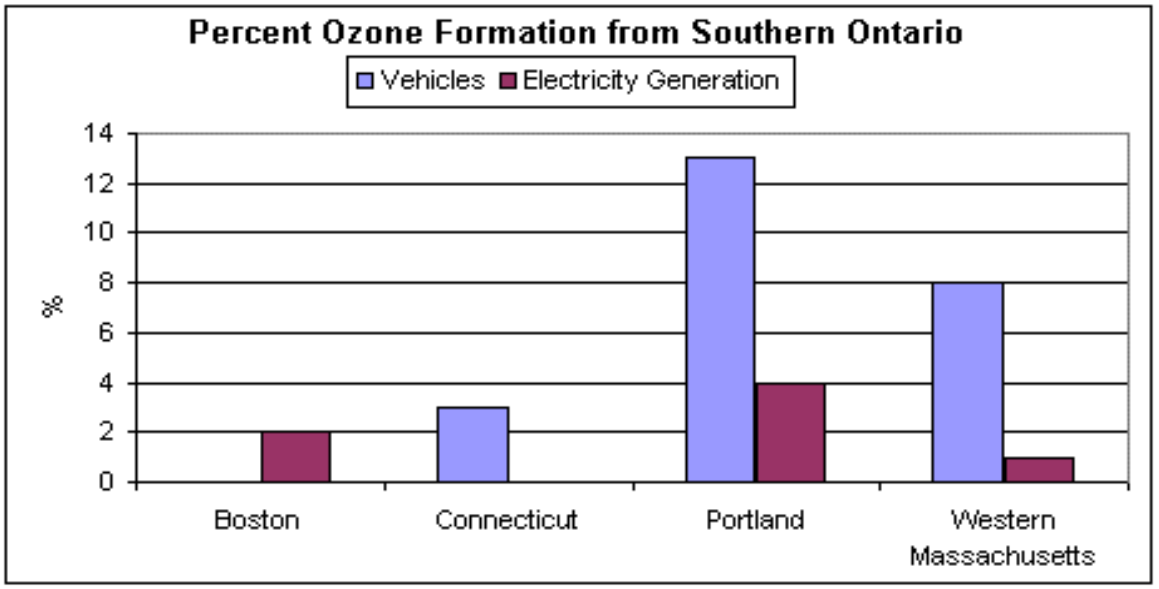
Ozone Sources of Smog-Producing Pollutants Affecting Southern Ontario



Source: Stratus Consulting Inc., 1999

In addition to receiving air emissions from the U.S., Southern Ontario is also a contributor, although to a lesser extent, of air emissions to downwind states. Figure 8 shows Southern Ontario's contribution to ozone formation at four U.S. locations.

Figure 8



Overall, Southern Ontario emissions from vehicles contribute from 0% to13% to ozone formation in Boston and Portland nonattainment areas in US. The maximum Ontario's fossil generation contributes to US is in Portland where 4% of the ozone during high smog conditions is attributed to Ontario.

Based on the above analysis, if Ontario were to shut down all of its fossil-fired electricity generating plants, it would only have a 2% impact on the overall ozone in the Southern Ontario region. The major impact in US will be a 4% reduction of ozone formation in Portland. Conversely, if all fossil-fired electricity generating plants in the central U.S. were shut down, the potential impact could be an ozone reduction in Southern Ontario of 27%.

It is clear that as the electricity industry is deregulated over the next few years and electricity would flow freely between regions, NAFTA could have a direct impact on air quality through its effects on fossil generation in both countries.

Canada and US, recognizing early on that they cannot solve their air quality problems simply through domestic action alone, have tried to address the air quality issues through bilateral agreements. The first was signed in 1991 and addressed the acid rain issue. The second is expected to be signed before the end of the year and will address the NOx emissions that contribute to ozone formation.

5.0 Environmental Regulations in Ontario/Canada and US

This section will examine the major environmental regulations in Canada and US that affect electricity generation. In a competitive electricity market, where electricity trade is expected to increase, differing levels of emission limits may affect competitiveness. If one country or province/state establishes significantly different environmental performance levels in certain areas could undermine the competitive position of the electric utilities. This issue is explored more in the following sections.

5.1 U.S. Environmental Regulations

The US environmental regulations are very complex to be analyzed in this paper. They span from the federal to regional and state as well as local level. This overview will be limited to the 1990 Clean Air Act Amendments (CAAA) applicable to air emissions from fossil fired stations.

There are three main initiatives under the CAAA that affect the air emissions of electricity producers in the U.S.: The Acid Rain Reduction Program, the Ozone Transport Commission Regulations, and the Environmental Protection Agency's NOx State Implementation Plan Call (NOx SIP Call). Although some states have developed their own environmental regulations, they will not be discussed in this report because their emission standards usually fall within the standards of the CAAA.

5.1.1 The Acid Rain Reduction Program

The Acid Rain Reduction Program was established by the Clean Air Act and is being implemented in two phases; Phase I began in January 1995 and targeted the largest electric industry sources (261 generating units) to reduce SO2 emissions. Phase II began in January 2000 and affects all fossil-fueled power plants larger than 75 MW. Under Phase II, power plant emissions of SO2 will be capped at 8.9 million tons per year. This is equivalent to an emission rate of 1.2 lb/mmBTU.

As part of the Acid Rain Program, the EPA (Environmental Protection Agency) has implemented a program of emission allowance trading for SO2 as a means for generators to meet their obligations under the Clean Air Act. The U.S. program is known as a cap-and-trade program, whereby the EPA sets an emissions cap and allowances are distributed to the various utilities, up to the level of the cap. An allowance is an authorization for that utility to emit one ton of SO2 during a given year or any year thereafter (i.e. allowances in this program can be banked indefinitely). At the end of each year, the utility must hold a number of allowances equal to its emissions of SO2 for the year. Utilities that reduce their emissions of SO2 may choose either to bank their allowances for future years or to sell them either on the open market or through EPA auctions.

The utilities have been very active in SO2 emissions trading in Phase I of the CAAA and have banked more than 10 million tons of SO2 emission allowances that will be used to comply with the Phase II SO2 requirements. In this way, as it will be shown later on, they plan to delay the installation of scrubbers to reduce the SO2 emissions to the Phase II emission levels.

The Acid Rain Program also contains technology-based standards for NOx emissions, designed to reduce these emissions by 2 million tons below 1980 levels. Phase I annual emission limits for NOx was 0.50 lb/mmBTU for dry bottom wall-fired boilers, or 0.45 lb/mmBTU for tangentially fired boilers. Phase II limit for NOx is 0.46 lb/mmBTU for dry bottom wall-fired boilers and 0.40 lb/mmBTU for tangentially fired boilers.

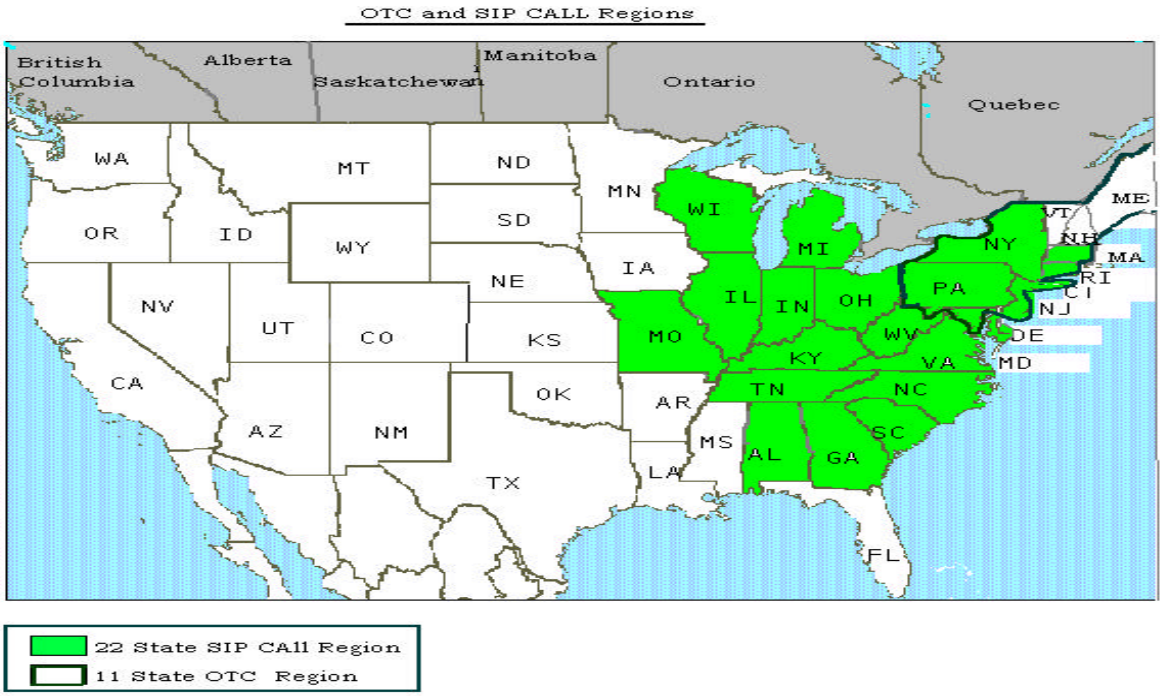
It should be noted that CAAA does not impose a total NOx cap and does not allow for NOx emissions trading. As a result, the certainty and pattern of NOx mass reductions vary from year to year depending on utilization of sources. While it offers advantages, a rate-based control program does not achieve the consistent level of NOx reduction achieved under a firm budget. The cap-and-trade approach provides more certainty regarding the limit on aggregate emissions over the life of the program regardless of unit level emission rates.

5.1.2 Ozone Transport Commission (OTC)

The second groups of regulations affecting NOx emissions by electricity generators are the regulations of the OTC. Figure 9 shows the 11 northeastern most states that comprised the OTC region. This region is classified by the EPA as a non-attainment

region, meaning that the region does not meet federal air quality objectives. The OTC's objective is to implement regulations in order to help the region meet federal air quality standards. The OTC NOx Budget requires two phases of reductions: compliance with first phase begun during the 1999 ozone season (May 1 through September 30) and calls for 55% reduction from 1990 levels. Compliance with the second phase will begin during the 2003 ozone season and will require a 70% reduction in NOx from 1990 levels to 143,000 tons. The 11 OTC states can meet their NOx budgets by installing NOx control technologies or using emissions trading.

Figure 9



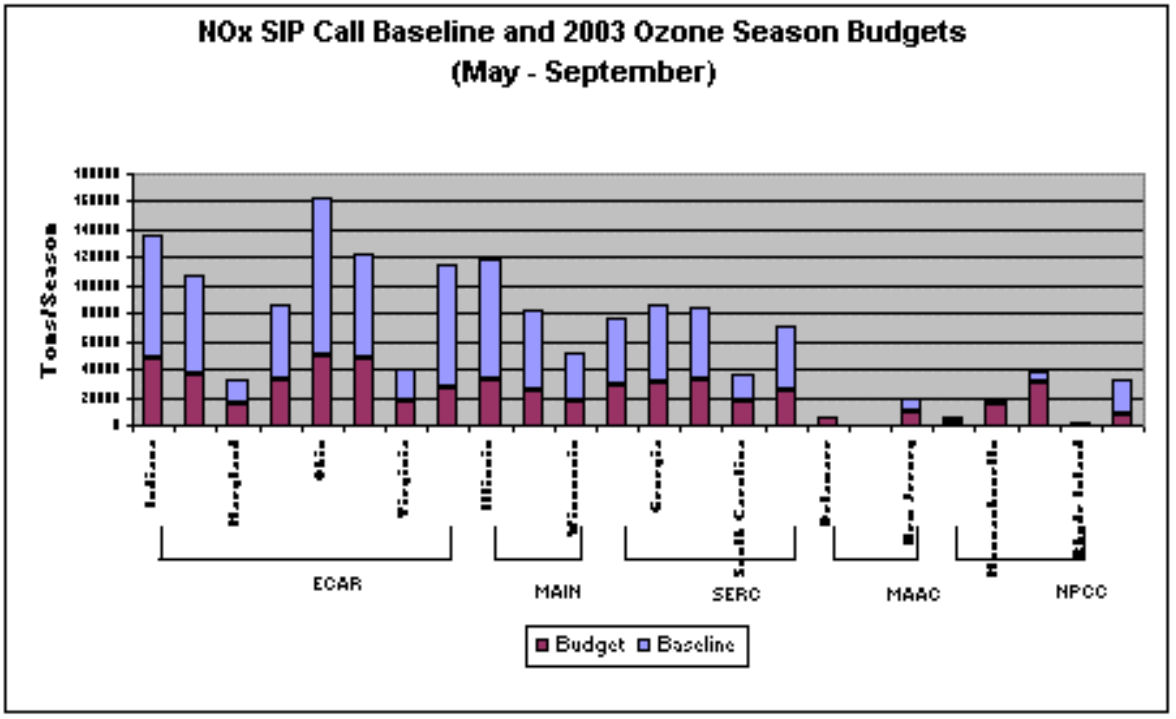
5.1.3 NOx State Implementation Plants (SIP) Call

As it was discussed earlier on, air pollution is transboundary in nature and is carried by prevailing winds. The U.S. Environmental Protection Agency (EPA) determined that a significant portion of the air pollution in the OTC region was the result of emissions from more Midwest states. Extensive air pollution modeling has shown that the eastern states would be unable to meet national air quality objectives without significant reductions of NOx emissions in the Midwest. The EPA therefore decided to implement a NOx SIP Call, establishing a limit for NOx deemed low enough to allow all the states to be in attainment of national sir quality objectives and demanding that the 22 affected states and the District of Columbia develop implementation plans for these limits. The SIP Call budgets are based on an emission rate of 0.15 lb/mmBTU NOx designed to result in a NOx reduction of 70% from 1990 emission levels over the summer period (May to September). Based on the SIP Call regulations the states are allowed to develop NOx emissions trading programs to meet their budgets.

The SIP Call uses a modeling system to project state's emissions in the year 2007 if no action were taken to reduce emissions. The resulting emission level becomes the baseline from which reductions are measured. A second model is run to determine what level of emissions would be required to allow all SIP Call states to attain the EPA's ambient air quality standards and therefore bring all "non-attainment" areas into "attainment" with the standards. This number becomes the state's NOx budget. The NOx budget is the equivalent of an emissions cap for the state. Therefore, generating units are allowed to pollute up to the NOx budget level for the entire state. It will be up to the states to assign NOx budgets to the individual generators, so that the overall state budget can be met

Table 10 below shows the baseline estimate and the NOx budget allocated to each state included in the SIP Call.

Figure 10



Ontario is included with a hypothetical NOx budget corresponding to 70% reduction of NOx emissions associated with 40 TWh of fossil generation from Ontario Power Generation and 10 TWh from private generators. If Ontario applies the SIP Call rate of 0.15 lb/mmBTU its emissions over the ozone season (April to September) will be reduced to approximately 10,000 tons, the lowest among the ECAR, MAI N and SERC states as well as New York.

The NOx SIP Call is currently being challenged in the courts. Industry presented the first challenge, claiming that the EPA did not have the jurisdiction to implement such rules. Their initial challenge was successful, but the EPA had that decision reversed on appeal. In September, in a new decision regarding the time of implementation, the courts delayed the implementation of SIP Call until 2004. It is expected that the SIP Call will be

challenged up to the Supreme Court, but that it succeed in the end and be implemented before 2005.

5.2 Ontario/Canada Environmental Regulations

In contrast to US where the EPA develops regulations that apply across the country or to specific regions, in Canada the provinces usually take the lead in developing environmental regulations within the environmental framework and standards set by the Federal Government under the Canadian Environmental Protection Act.

The Ontario Environmental Protection Act (OEPA) is the Province's most comprehensive environmental law, and is the primary legal authority for controlling air emissions in the province, including that arising from coal-fired electric stations. The OEPA is administered by the Ministry of the Environment.

The major air emission regulations are part of the Province's Countdown Acid Rain Program. Under this program, the province of Ontario has used a system of emission caps to regulate air emissions from the major industries including the electricity sector. Trading and banking emissions are not allowed. This is in contrast to US regulations, which tend to focus more on emission rates or use aggregate emission caps with emissions trading.

New emission caps were proposed in January 2000 for NOx (61,000 tons) and SO2 (174,000 tons). The emission cap for NOx is equivalent to the CAAA Phase II emission rates while the SO2 cap corresponds to a lower emission rate than that mandated by the Phase II of the CAAAA.

In addition to these domestic caps, the government has also proposed equivalent emission performance standards of 4.39 lb/MWh for NOx and 10.14 lb/MWh for SO2 to be applied to all electricity generated or sold in Ontario by coal or oil fired plants greater than 25 MW. As a result, all foreign producers will be required to meet provincial standards for air emissions before being allowed to sell electricity in Ontario.

The Ontario government has also made a commitment to matching any EPA-issued emission limits if they are stricter than the current Ontario limits. In essence, the provincial government has pledged to meet or exceed the SIP Call limits once they are implemented in the U.S. This will require Ontario generators to make further reductions in NOx emissions.

A formal Emissions Trading Program does not exist in Ontario, although it is proposed in the new regulations. Instead, Ontario has developed a Pilot Emission Reduction Trading (PERT) program. This is a voluntary, multi-stakeholder program involving industry, government, and environmental organizations. Unlike the U.S. program, there is no initial distribution of emission allowances. Rather, participants in the program earn credits for emission reductions below a historical level that has met the provincial or federal regulatory limits. These credits can then be used towards meeting provincial

emission limits or voluntary reduction targets. Excess credits can be traded on the open market. Emission reductions are verified by an independent auditor to ensure their authenticity. To date, the program has developed markets for NOx, SO2, and CO2 equivalents. The Ontario's PERT program is expected to be incorporated into the "Cap, Credit and Trade System" proposed in the new environmental regulations that are under development.

Because emission trading in Ontario is relatively new and is operating only as a pilot program, companies have not had the opportunity to earn and bank credits for their emission reduction activities over the years. This is in contrast to the U.S., which has had emissions trading for many years. While Ontario's generators were reducing emissions in order to comply with the legislation, their US utilities were earning emission allowances for the same activities. Now, as the EPA implements tougher SO2 emission standards, as part of Phase II of the CAAA, the American utilities have over 10 million tons of banked emission allowances to begin to draw from. Ontario generators on the other hand have no such a bank, although they have made proportionally equal or greater reductions in their emissions. This could affect the level playing field of electricity generators as the electricity markets open to competition.

In addition to the above emission regulations, in anticipation of competitive electricity markets in Ontario, the government of Ontario will require the mandatory tracking and reporting of all harmful emissions starting in 2001. Under this mandate, all generating facilities of more than one megawatt will be required to report their emissions as well as the type of fuel used and the amount of electricity they generated over a 12-month time period.

5.3 Other Environmental Regulations

Standards for Mercury, PM10 and PM2.5 particulates are under development in Canada as part of the Canada-Wide Standard process and in US under the authority of the Environmental Protection Administration (EPA). In addition, both countries are investigating various strategies to comply with the Kyoto agreement to reduce CO2 emissions.

Although the processes are moving in parallel in the two countries, there is a need to harmonize the time frame for monitoring, developing the emission limits and implementing the programs in order to maintain a level playing field among the electricity generators in an open electricity market.

To avoid potential effects of electricity restructuring on air emissions, many states have included environmental provisions in state restructuring laws. State and federal energy regulators are using three mechanisms to support clean technologies and help reduce air emissions in the transition to a competitive industry.

System Benefit Charges: a per kWh surcharge on electricity is used and the proceeds are used to support renewable or energy-efficiency projects.

Renewable Portfolio Standards: A requirement that retail electricity suppliers provide a certain percentage of their kWhs from emerging cleaner resources.

Emission Portfolio Standards: It requires all electricity suppliers in the state to meet portfolio average emissions standards for NOx, SO2 and CO2.

There is a need to harmonize the definitions of these standards in order to avoid undermining unfairly the competitive position of electricity generators in the two countries.

It is evident from the analysis above that the environmental regulations of the two countries have converged significantly over the last few years. There is a need however, for further harmonization of environmental regulations and emission trading mechanisms used for compliance in order to maintain a level playing field in the electricity markets.

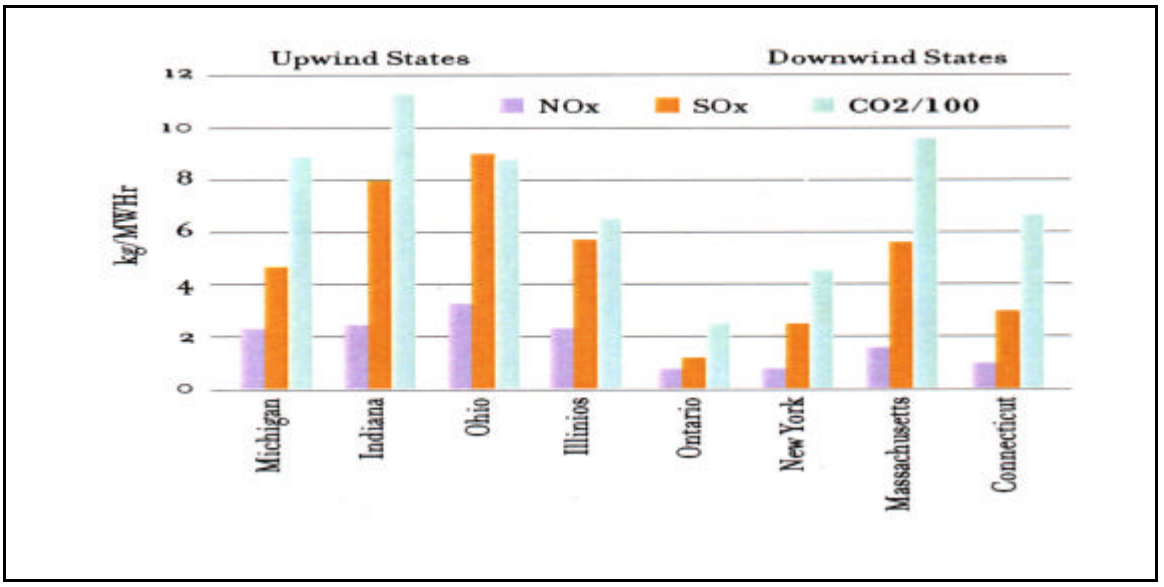
6.0 Air Emission Profiles of Ontario and ECAR Region

The SO2 and NOx emissions produced by the states in the ECAR region and Ontario are discussed in detail below.

Figure 11 compares Ontario's emissions with the emissions in the upwind and downwind states. Ontario's emissions per unit of electricity are lower than any other electrical producer in Ontario's regional airshed and among the lowest of all electricity producers in North America.

Figure 11

Airshed Emission Rates for NOx, SO_2 and CO_2



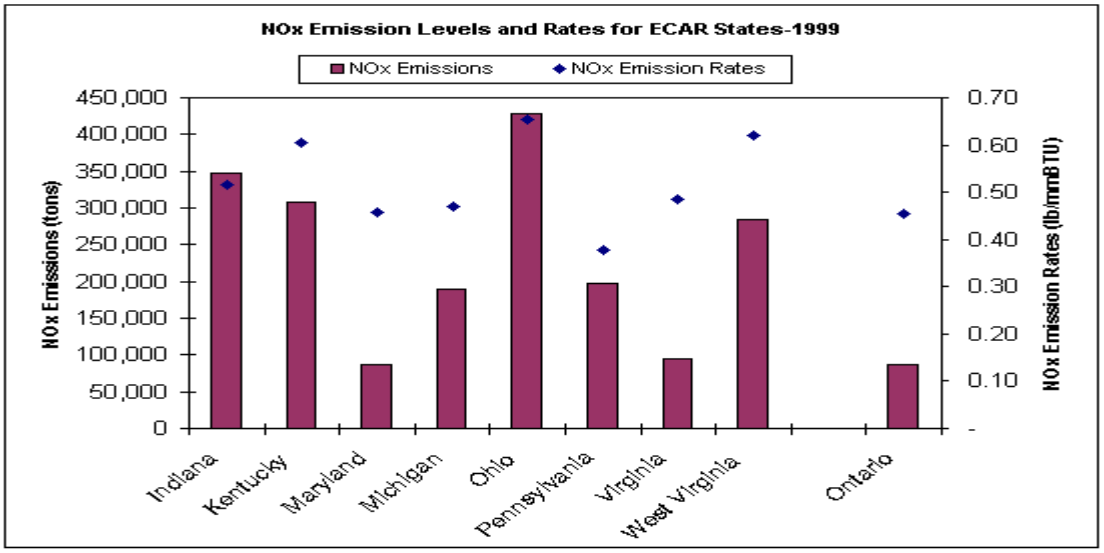
Source: Clean Air Corporation, 1999

Ontario's emission rates are lower because of its diverse generation mix, which includes nuclear, hydroelectric and fossil energy. In contrast, electricity producers in neighboring U.S. states that share Ontario's airshed rely primarily on fossil fuels to meet the electricity demand. The SO2 and NOx emission trends in ECAR and Ontario are discussed below.

6.1 Comparison of NOx Emission Trends in ECAR Region and Ontario

Figure 12 compares the 1999 NOx emission levels (left vertical scale) and NO_X emission rates (right vertical scale) of the ECAR states with that of Ontario.

Figure 12

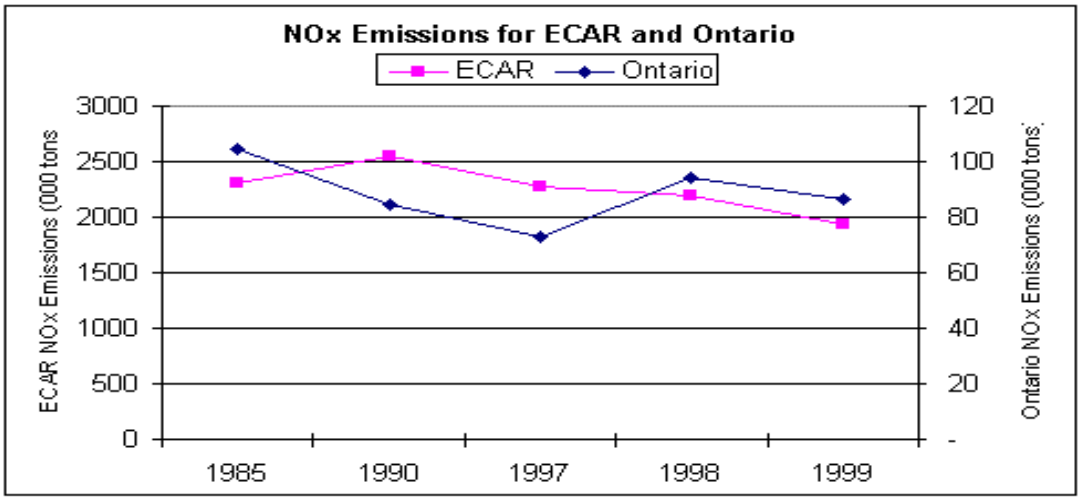


Ohio, followed by Indiana, West Virginia and Kentucky states produced the largest amount of emissions and they also have the highest emission rates among the ECAR states. Ontario had the lowest NOx emissions together with Maryland and Virginia states. Pennsylvania has the lowest NOx emission rate while Ontario is in the middle of the pack together with Maryland and Michigan states. It is expected that the NOx emission rates will be reduced further in 2000, as the utilities are required to meet the CAAA Phase II standards that range from 0.40 to 0.46 lb/mmBTU depending on the type of boiler used.

Figure 13 shows historical NOx emissions for ECAR on the left vertical scale and Ontario on the right vertical scale. It should be noted that the scale on the left is about 30 times larger than the scale on the right. The ECAR emissions have declined by 16%, from 2.3 million tons in 1985 to 1.9 million tons in 1999. The decline in 1997 onwards is

the result of the CAAA Phase I limits that came into effect in 1995. The downward trend continues over the last three years as utilities install Low NOx Burners and other NOx controls in preparation for the Phase II of the CAAA that came into effect on January 1, 2000.

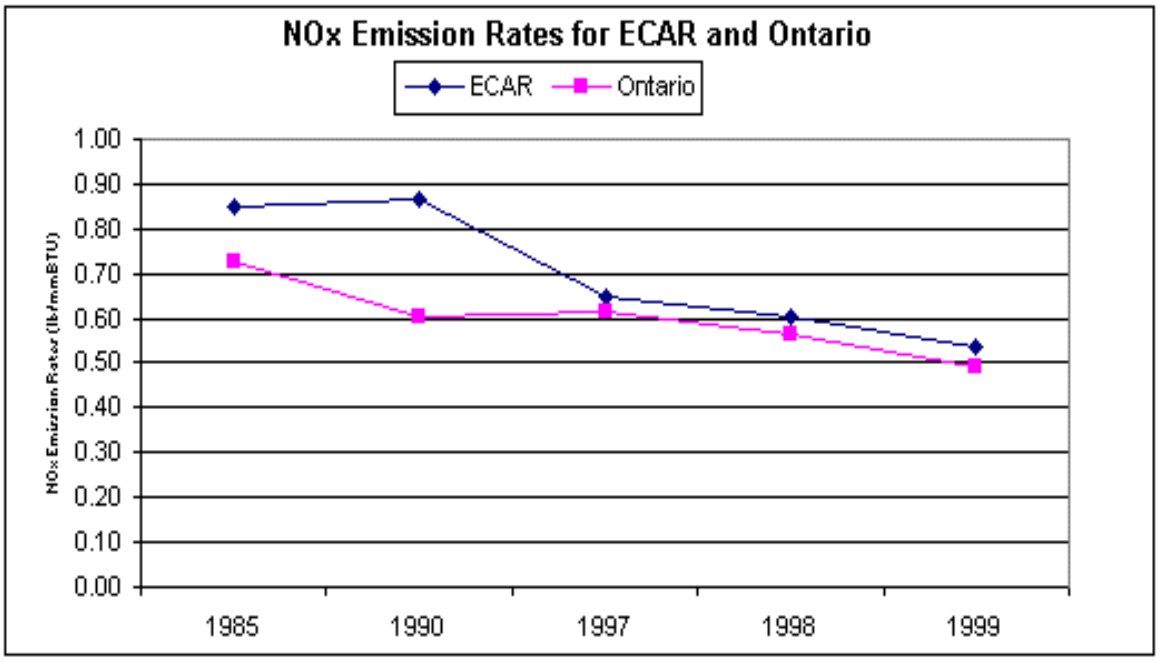
Figure 13



Ontario's NOx emissions declined by 17% between 1985 and 1999. By the middle of 1990's the NOx emissions had been reduced by 45% but they have gradually increased recently in part because of the greater demand imposed by the temporary layup of eight nuclear units as part of OPG's Nuclear Improvement Plan.

Figure 14 shows the NOx emission rates for ECAR and Ontario

Figure 14



Although NOx emission rates have declined for both regions over time, Ontario's emission rates are consistently lower than ECAR's throughout the 1985 to 1999 period. Environmental improvements such as low-NOx burners, continuous emission monitors, smart computer control systems, and the conversion of oil-burning units to also burn natural gas, have helped to reduce Ontario's NOx emission rate by 33% since 1985. It is expect that further investments over the next two years will reduce NOx emissions by an additional 10% to 15% by 2002.
The NOx emission rates in the ECAR region have been reduced by 36% since 1985 and are expected to be reduced further in 2000 as the CAAA Phase II limits of 0.40 to 0.46 lb/mmBTU come into effect.

It should be noted here that in the US the CAAA Phase II NOx standards are based on emission rates and as a result they do not limit the generation level. In Ontario the NOx limit is based on an emissions cap of 61,000 tons, which cannot be exceeded without the purchase of emissions credits as was discussed in Section 5. This could impose additional costs to the electricity generators in Ontario.

The analysis above has shown that as the electricity markets open to competition in the coming years, the electricity generators in ECAR and Ontario will face similar NOx emission rate limits. The emissions cap system used in Ontario however could burden the electricity generators in Ontario with the purchase of emissions credits and put them in a disadvantage position relative to the US generators.

6.2 Comparison of SO2 Emission Trends in ECAR Region and Ontario

Figure 15 compares the total SO_2 emissions and emission rates for the ECAR states with Ontario. Ohio has by far the largest amount of SO2 emissions followed by Pennsylvania and Indiana while Ontario has the lowest SO2 emissions. The SO2 emission rates follow the same pattern with Ontario again being the lowest. The emission rates are not expected to be reduced immediately starting in 2000 as the Phase II of the CAAA comes into effect, because utilities have banked SO2 allowances that they plan to use over the next two to three years.

Figure 15

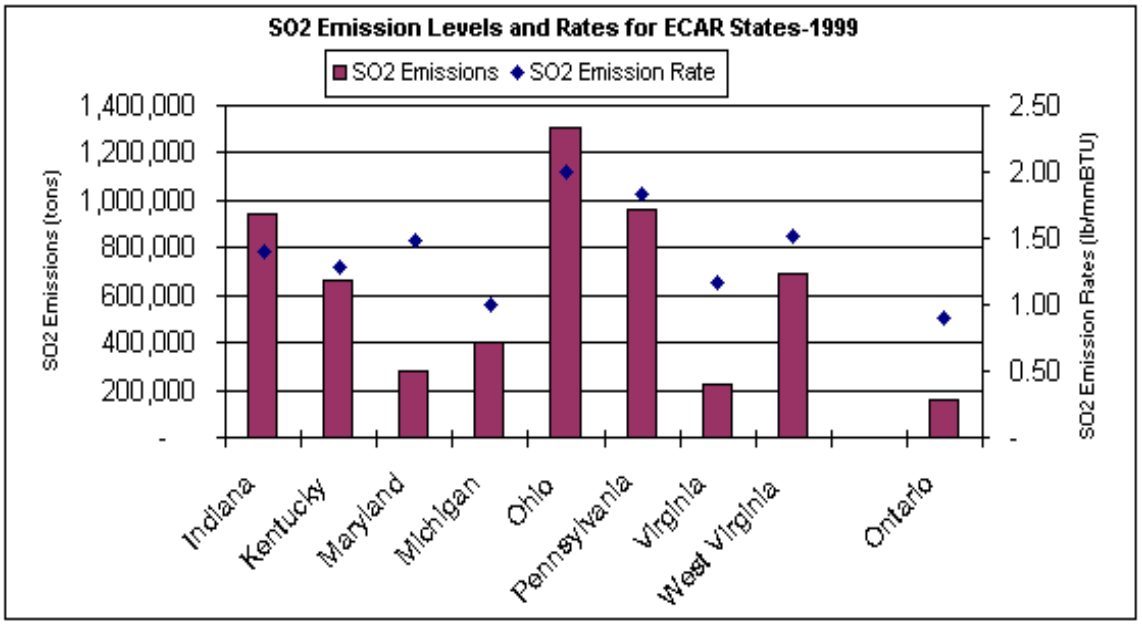
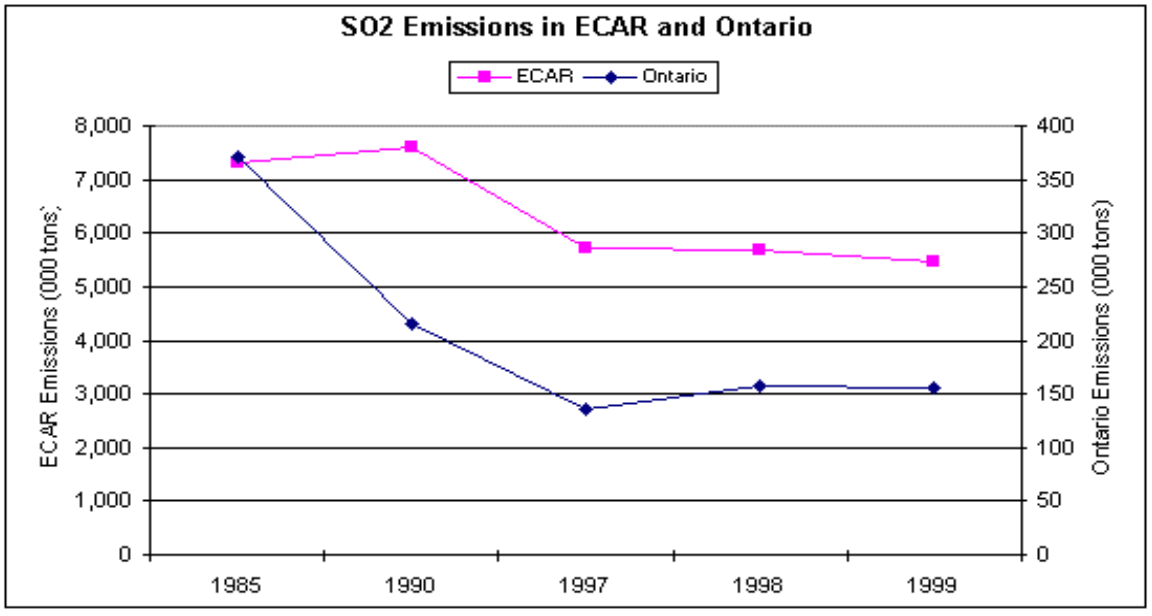


Figure 16 shows the ECAR and Ontario SO2 emissions on the left and right vertical scales respectively. The ECAR region produced in 1999 5.5 million tons of SO2, which is roughly 20 times the Ontario emissions and account for 44% of total US emissions from fossil generation. The SO2 emission rates have declined by 32% since 1985 in the ECAR region vs 58% in Ontario.

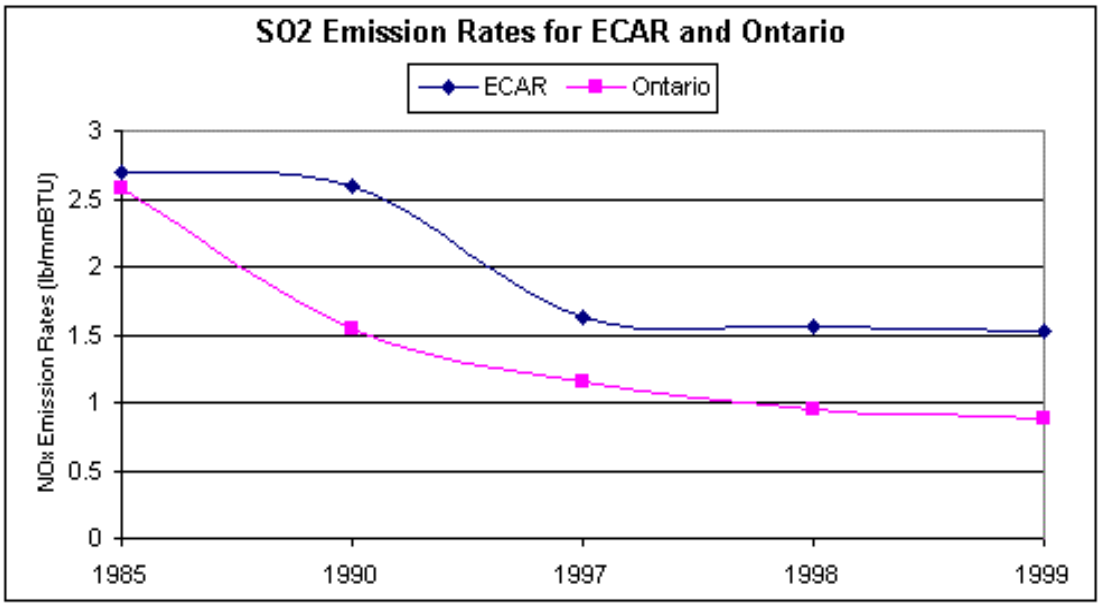
Figure 16



Ontario has achieved these reductions by converting oil-burning units to burn natural gas, increasing the use of low-sulfur coal, and installing scrubbers in one coal fired station. As the nuclear units return to service over the next few years SO2 emissions in Ontario are expected to decline again. Similarly, the ECAR generators have installed scrubbers and switched to low sulfur coal to reduce SO2 emissions.

Figure 17 shows the SO2 emission rates for ECAR and Ontario. Ontario's SO2 emission rates are consistently lower than ECAR's over the 1985 to 1999 period with the gap widening to 42% by 1999.

Figure 17



This difference reflects the leadership role that Ontario took in early 1990's to tackle the acid rain problem. It is interesting to note that Ontario already exceeds the CAAA Phase II rate of 1.2 lb/mmBTU for SO2. In ECAR region, the major reduction in SO2 took place in 1995 when Phase I of the CAAA came into effect.

As the electricity markets open, the US utilities will have a competitive advantage in the control of SO2 over the Ontario generators, since they will be able to use their banked SO2 emission allowances and delay investing in costly SO2 control technologies to comply with the Phase II of the CAAA.

7. Impact of Environmental Regulations on Coal Generation, Air Emissions and Trade of Electricity

In this section results from two studies that Ontario Power Generation has conducted with assistance from external expert consultants will be discussed. The studies were undertaken to address specific strategic issues pertaining to electricity deregulation in Canada and US and its impact on electricity generation in Ontario. As a result, only a portion of the findings relevant to this report has been extracted from these studies.

7.1 Modeling of the North America Electricity System under Open Competition

The first study was undertaken by Hill & Associates, a US consulting firm specializing in modeling and forecasting coal demand and electricity generation. The study modeled the behavior of utilities in the United States and Canada under competitive market conditions and different environmental scenarios over the 2002 to 2007 time period. The model considered environmental and transmission constraints, specific characteristics of generation plants, fuel costs and emission control costs under various environmental scenarios. From these variables, the model generated projections about fossil generation, emissions, compliance strategies, price, and imports and exports.

The model forced utilities to remain within national or regional pollution limits. In order to comply the model allows the utilities to switch to lower sulfur coals, trade emissions allowances, install emission control equipment, and manipulate the load factor for each plant.

The model is composed of two pieces, the Utility Fuel Economics Model (UFEM) and the National Power Model (NPM). The actual running of the integrated model is an iterative process for each year run, requiring first a set of fuel and clean-up choices (from the UFEM), followed by a decision on how heavily to dispatch each plant at those particular fuel costs and emission rates (from the NPM). Once the plants are dispatched by the NPM in the most economic manner (while staying within the total national or regional pollutant limits), the amount of generation required of each coal plant is then fed back to the UFEM model where new fuel and clean-up choices are made, given this updated load on each plant. As these new fuel choices are made, yielding new fuel costs and emission rates for each plant, these are fed back over to the NPM model, which re-dispatches all plants. This loop continues until convergence is reached with no significant change occurring in each model's results during a new loop. Thus, the model is not just finding which fuel provides the lowest cost per million Btu's of heat input – it is answering the question of whether the plant actually dispatches with that fuel's costs (including necessary clean-up costs) and emission rates of SO_2 and NOx.

PHB Hagler Bailly, a consulting firm specializing in energy studies and modeling the electricity system of North America, undertook the second study. The GE MAPS model was used to model the Eastern Interconnection electricity system of US, including Ontario. The model contains detailed information on generating stations and transmission lines in the areas it models. Information on generation facilities includes the location of the stations, capacity of the stations, their fuel efficiency, start up costs, fixed and variable operating costs, and technical data such as forced outage rates. For transmission systems, data include the capacity of the available transmission lines, the

nodes at which they intersect, the connection points of generators, and the demand points for load. New plants enter the system only when the average price over a year is sufficient to pay their full costs, including capital costs. In an hourly competitive market generators are expected to supply electricity at any price that covers their incremental generation cost. Since that cost will not also cover capital costs, generators must expect higher prices at some times of the year if they are to believe that they can make an overall profit. This representation of the physical system forms the basic model.

The GE MAPS model solves for the optimal dispatch, given the resources available, in each period of the day. The model solves every other hour for a year. At each solution time, the model dispatches the resources that will most cost effectively satisfy the load.

The GE MAPS model also included assumptions about electricity demand forecasts, fuel prices and open electricity markets over the next 10 years that were generally consistent with the assumptions used in the Hill model under the NAAQS Case. The Hagler Bailly study however, focused on the 2005 to 2012 period rather than the 2002 to 2007 period addressed by the Hill study.

7.2 Environmental Scenarios

The impact of future environmental regulations on fossil generation and trade of electricity were assessed using two environmental scenarios:

Base Case: This case imposed the restrictions of Phase II of the Clean Air Act Amendments (CAAA). In the year 2000 SO_2 was limited to 1.2 lbs/mmBTU and NO_x was limited to 0.40-0.46 lbs/mmBTU depending on the type of boiler. For the eleven states in the Ozone Transport Commission (OTC) Region further emission reductions were imposed. For Ontario, a cap of 193,000 tons on SO2 and 64,000 tons on NOx was imposed. (Since the study was completed, the government of Ontario has proposed that the SO2 and NOx caps for Ontario will be reduced to 174,000 tons and 61,000 tons for SO2 and NOx respectively effective in 2001).

NAAQS Case: This case imposed the more stringent 22 State Implementation Plan (SIP Call) restrictions proposed by the EPA in order for states to meet the National Ambient Air Quality Standards (NAAQS). In the year 2003 NO_x was reduced to 0.15 lbs/mmBTU. The SO2 limits were assumed to be the same as in the Base Case over the 2002 to 2007 study period. For Ontario, the NOx limit was set to a flat cap equivalent to 0.15 lbs/mmBTU while the SO2 limit remained the same as in the Base Case.

7.3 Impact of Environmental Regulations on Coal Generation and Air Emissions

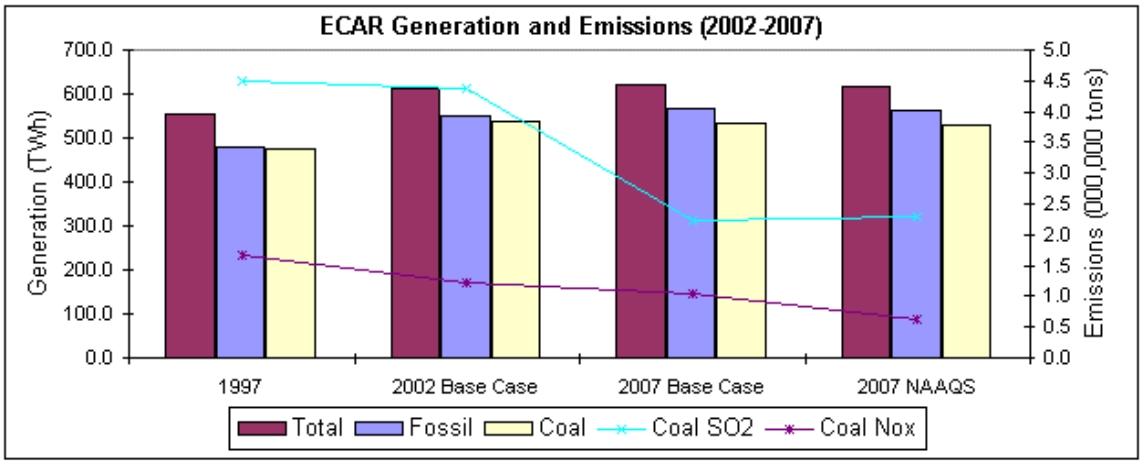
First the results from the Hill study will be reported followed by the results from the Hagler Bailly study.

The increased capital and operating costs to coal-fired generation under the NAAQS Case relative to the Base Case were estimated to be $1 billion per year by 2007. These costs are above and beyond the clean up costs associated with the new NOx and SO2 limits imposed by the Phase II of the CAAA starting in 2000. With current total annual US generation costs (including capital) in excess of 70 billion, the incremental cost for cleaning up under the NAAQS Case is not expected to have significant impact on the overall cost of power in the US. However, because the financial impact will be concentrated in the coal-dominated Midwestern and southeastern portions of the US, generators in these regions will have to invest a high amount of capital in emission control equipment in order to maintain their business.

As it was discussed in the previous sections, the region of highest interest for this study is ECAR as it is one of the major Ontario's direct trading partners in the U.S. and its generation is dominated by coal.

Figure 18 shows, for the Base Case and the NAAQS Case, the ECAR region's total expected generation and coal-fired generation (bar chart reading off the left vertical scale) as well as the tons of SO_2 and NOx emitted from ECAR coal plants (solid lines reading off the right vertical scale).

Figure 18



Although the Phase II of the CAAA came in to effect in 2000, the SO2 emissions are not expected to be reduced significantly as the utilities have accumulated significant amount of SO2 allowance after over-complying with Phase I emission limits. As a result, utilities are expected to postpone major investments in reducing SO2 by two to three years. Another factor keeping 2002's SO_2 emission level up is the fact that utilities in general are postponing the hard big-ticket capital decisions (like installing scrubbers) in the face of deregulation uncertainty and environmental uncertainty. After the SO2 bank has been exhausted and several new scrubbers are built between 2002 and 2007, the ECAR's coal-fired SO_2 emissions finally drop in response to the acid rain limitations of Phase II.

Looking at the NOx trend in ECAR under the Base Case, without a bank of allowances to draw down (as was the case for SO_2), NOx clean up begins immediately with the

implementation of the CAAA Phase II standards. As a result, the 2002's NOx tons emitted from coal plants is significantly lower than 1997's emissions despite coal generation having grown about 8%. Then as coal-fired generation remains basically stable from 2002-2007 and NOx clean up continues, the total annual tonnage of NOx emitted from coal-fired plants drops further to approximately 1 million tons. Under the NAAQS Case the NOx emissions have been reduced by more than 65% to 600,000 tons in 2007.

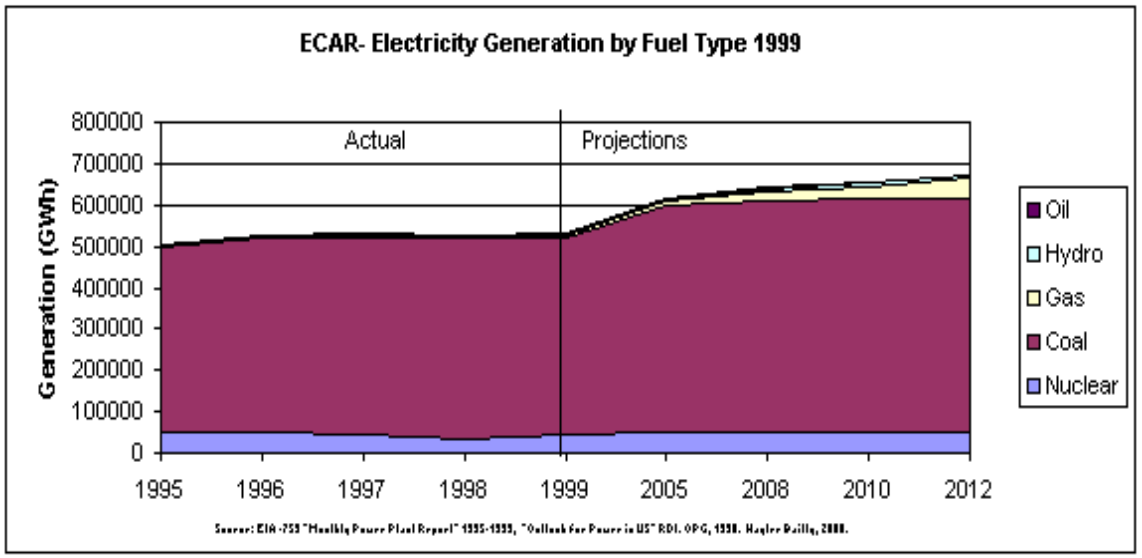
It is interesting to note that the amount of coal-fired generation is basically the same for the Base Case and the NAAQS Case in the ECAR Region in 2007. The NOx emissions however, have been reduced by more than 40 % relative to the base case. This indicates that the clean-up costs have been incurred but are not high enough to reduce coal-fired generation over this period.

Note that although it has been expensive to achieve this clean up, the coal generation in the ECAR region has not decreased. This indicates that the NOx and SO2 clean up costs are not high enough to reduce coal generation. As a result, coal is expected to continue dominating the electricity generation in the Midwest even after the most stringent environmental regulations have been implemented.

The findings of the Hill study were supported by the Hagler Bailly study. The modeling results over the period 2005 to 2012 have shown that, even under the NOx SIP Call environmental regulations and competitive electricity markets, the goal generation will continue to be the fuel of choice in the Midwest and the ECAR region in particular.

Figure 19 shows that coal generation will increase by 15 from 1999 to 2005. As the NOx SIP Call comes into effect the generation from coal will stay relatively constant at 2005 level over the study period.

Figure 19

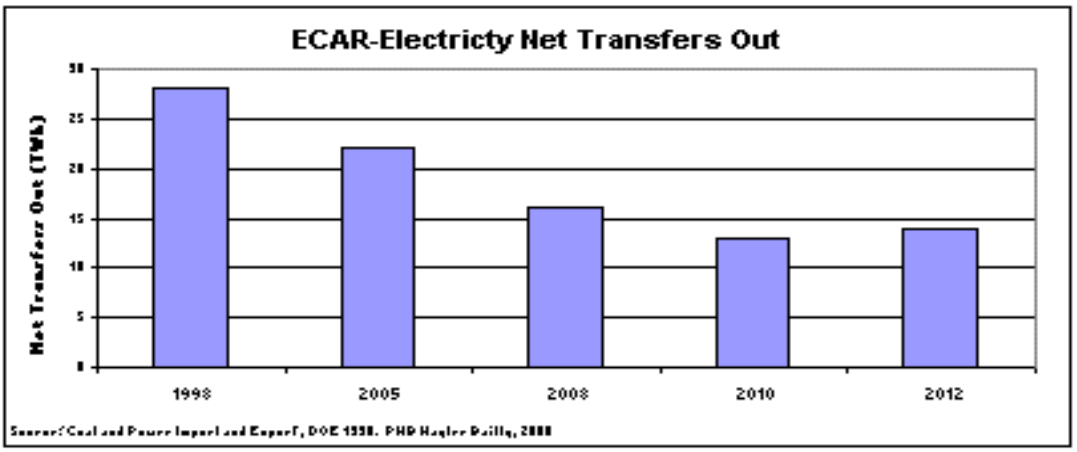


Both studies have found that under competitive market conditions in the electricity sector the coal generation will not decrease over the next ten years. The SO2 and NOx emissions however, will be reduced drastically as the CAAA Phase II limits come into effect and the NOx SIP Call limits are implemented. It should be noted that if the electricity markets were opened to competition before the implementation of the NOx SIP Call limits the air emissions from the Midwest states could increase and will have a negative impact on air quality in Canada and Northeast US.

7.4 Impact of Electricity Deregulation on Electricity Trade

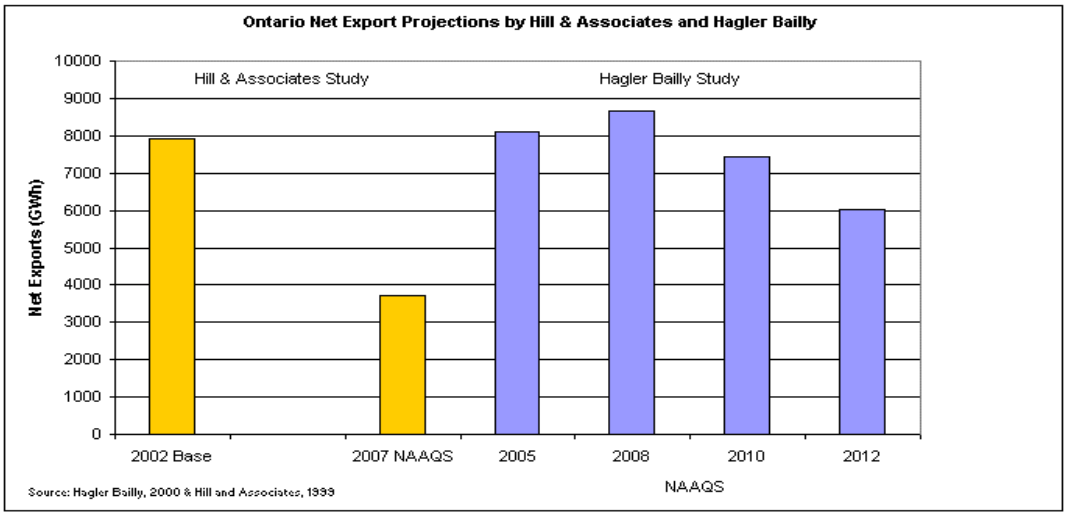
Figure 20 shows that the electricity "transfers out" from ECAR to other regions could decline as much as 54 %, from 28 TWh in 1998 to less than 13 TWh by 2010. One of the major reasons for this decrease is the NOx SIP Call limits that come into effect before 2005. In addition, the electricity demand will grow within the ECAR region and as a result will decrease the availability of generation for "transfers out". The expected reduction of ECAR "transfers out" is an indication that the electricity restructuring will not increase in the long run the flow of coal-generated electricity from Midwest to Northeast part of US.

Figure 20



Another indicator of the impact on environmental quality is the amount of electricity trade expected between Ontario and US under open access of electricity markets. Figure 21 shows the results from the two studies.

Figure 21



Both studies have estimated that Ontario will continue to be net exporter of electricity even when the SIP Call standards (NAAQS Case) are applied throughout the region.

The Hill study estimated that electricity exports could increase to 8 TWh by 2002. As the SIP Call comes into effect, the net electricity exports are reduced below the 5 TWh per year. The Hagler Bailly study estimated higher net annual exports ranging between 6 to 8.7 TWh over the 2005 to 2012 period.

These export levels are in line with the historical trends. In all cases the majority of electricity exported is to the ECAR (Michigan) and NPCC (New York) regions. The amount of imports from the US is expected to be small over the study period relative to the exports, which is indicative of the competitive advantage that Ontario has over the electricity producers in the neighboring regions.

Based on the above analysis, we could infer that the impact of free trade of electricity between Ontario and US is not expected to affect the air quality in Ontario if both countries follow through with their plans to implement the NOx SIP Call emission standards. In the short- run however, if open access takes place before the SIP Call comes into effect, the emissions could increase adversely affecting the air quality in Canada and Northeastern states.

8. Summary of Findings

The major findings of this study are summarized below:

- US produce about 66% of its electricity from fossil fuels vs 24% for Canada. The share of coal in electricity generation in the ECAR region is over 80% in comparison to 25% in Ontario.

- It has been estimated that more than 50% of the annual smog in Ontario is coming from US sources. Most recent research has shown that more than 80% of the ozone in Ontario during high smog conditions is caused by US sources of which, 27% is attributed to US electric utilities from the Midwest. Ontario emissions also contribute to smog in some US locations but to a much smaller degree ranging from 0% in Western Massachusetts to 4% in Portland.

- The deregulation of electricity markets has proceeded simultaneously in the two countries with full competition at wholesale markets expected to take place in the coming years.

- Environmental regulations for reducing NOx and SO2 had diverged in 1980's and early 1990's with Ontario and Canada taking a lead role in reducing acid gas emissions. With the implementation of Phase II of the CAAA in US that started on January 1, 2000, there is evidence that the environmental regulations for NOx have converged resulting in the Midwest utilities having average annual NOx emission rates very close to those of Ontario.

- Although both counties have made progress in SO2 reductions, Canada and Ontario in particular has made reductions early on so that it has met the Phase II CAAA limits since 1997. In US, the utilities will rely heavily into selling allowances that they accumulated by over-complying in the Phase I of the CAAA. As a result, they will avoid making significant capital (equipment) investments over the next two to three years to reduce SO2 emissions.

- The emission allowances programs for NOx and SO2 in particular have a long history in US, with electric utilities minimizing their costs of complying with environmental regulations. Although Ontario has an emissions credit program, it is at the pilot stage and has not been included as part of the environmental regulations yet.

- The use of coal for generation is expected to increase over the next 4 to 5 years. With the most recent decision by the US courts to delay the NOx SIP Call implementation until 2004, there is a risk that air emissions in US will increase in the short-term before they start declining again.

- Although it will be expensive to meet the NOx SIP Call standards for NOx, the coal generation in the Midwest and ECAR region in particular is not expected to be reduced even after the implementation of the NOx SIP Call regulations. The NOx emissions however, are expected to be reduced by more than 65% by 2007.

- Electricity transfers from ECAR region to the rest of US are expected to decline over time after the implementation of the NOx SIP Call.

- Ontario is expected to maintain its competitive position in the region with the electricity exports estimated to increase back to the historical levels as the nuclear recovery program is fully implemented.

- The deregulation of electricity industry in the two countries and the free trade of electricity between Ontario and its neighboring jurisdictions is not expected to adversely affect the air quality in the long run. This is true assuming that the NOx SIP Call emission limits will be in effect as the electricity markets open to competition.

9. Policy Considerations

Any policy considerations should take the following factors into account:

- Ontario and eastern US share common airshed and heavily interconnected electricity systems.

- The electricity generation mix is very different in Canada and US. This difference has resulted in significantly different air emission profiles. US facilities impacting Ontario's airshed rely heavily on fossil fuels.

- US sources of emissions have a significantly larger impact on Canadian air quality than the impact of Canadian emission sources on US.

- Both countries have made significant reductions in emissions and regulatory trends indicate that further reductions will be required in the near future.

- With the opening of electricity markets in both countries, environmental regulatory policies will influence the flow of electricity across the borders.

- Based on this analusis, it could be inferred that the impact of free trade in electricity between Ontario and US is not expected to affect the air quality in Ontario if both countries follow through with their plans to implement the NOx SIP Call emission standards. In the short- run however, if open access takes place before the SIP Call comes into effect, the emissions could increase adversely affecting the air quality in Canada and Northeastern US.

Taking the above factors into account, the following policy considerations are proposed to ensure a level playing field in the electricity markets and minimize future environmental impacts of electricity trade as the electricity markets open to competition:

- Regulations should take into consideration differences and potential impacts of air emissions between the two counties.

- The regulatory systems in Canada and US should continue to converge by harmonizing the air emissions standards, for the electricity generators to compete on a level playing field as the electricity markets open to competition.

- The emissions trading programs should be harmonized in order the generators in both countries to be able to take advantage of opportunities for reducing their emission at lowest cost.

- The two countries should establish a process for harmonizing the development of new regulations such as mercury emissions and long-term targets for SO2 and NOx emissions, as they address the PM_{10} and $PM_{2.5}$ particulates in the coming years. The new regulations should maintain the level playing field among the electricity generators as the electricity markets open to competition in the two countries.

- The definition of environmental provisions (i.e. renewable portfolio standards, emission portfolio standards) proposed to enhance cleaner technologies need to be harmonized to ensure a level playing field in the electricity markets.

10. Bibliography

"Environmental Benchmarking of Ontario Power Generation Fossil Plants", Hill & Associates, October 1999.

"Cost of Early Retirement of Coal Generation", Hagler Bailly, March 2000

Towards Sustainable Development, Ontario Power Generation Inc., 1999 Progress Report

"Source-Receptor Relationship for Ozone Formation in the Great Lakes Region of Canada and the United States: An Application of the Regional Economic Model for Air Quality (REMAQ) to Transboundary Pollution", Stratus Consulting Inc. July, 2000