Air Quality, Human Health & the Built Environment:

Protecting Air Quality through the Land Use Planning Process

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Executive Summary

Introduction

Poor air quality poses a significant public health risk to people living in southern Ontario. The five common air pollutants -- ground-level ozone, fine particulate matter, sulphur dioxide, nitrogen dioxide and carbon monoxide -- have been clearly and consistently linked to acute health impacts such as increases in non-traumatic deaths, hospital admissions for heart and lung conditions, emergency room visits, and asthma symptoms at concentrations that are commonly experienced in southern Ontario. A growing body of scientific literature indicates that these common air pollutants also contribute to chronic heart and lung diseases including lung cancer and asthma. While everyone can be negatively affected by poor air quality, the research demonstrates that newborns, children, the elderly, and people with pre-existing health conditions such as heart disease, asthma and diabetes are particularly sensitive to the adverse effects of air pollution.

There are five major sources of air pollution in Ontario: transboundary air pollution that is emitted in the United States; the transportation sector; fuel consumed for space and water heating in buildings and for the generation of electricity; industrial sources; and open sources such as road dust, quarries and general solvent use. While transboundary air pollution has a substantial impact on air quality in Halton Region, local and regional sources of air pollution that are within the influence of Halton residents and/or their local and regional governments also have a significant impact.

Vehicle-Related Air Pollution

Emission inventories indicate that the transportation sector is one of the most important sources of air pollutants and greenhouse gases within Halton Region, Ontario and Canada. In addition, a large number of traffic corridor studies have demonstrated that health impacts such as hospitalizations for asthma and deaths from strokes are significantly higher among those people who live in close proximity to busy highways than among those who live further away. While a great deal of progress has been made to reduce emissions from individual vehicles, this progress has been offset to some extent by the increasing number of vehicles on the road and the increasing number of kilometres travelled by Canadians.

Regional and local governments can help to reduce the number of vehicles on the road by encouraging the development of “complete communities” that can be efficiently serviced by public transit and alternative modes of transportation, providing efficient transit service within and between communities, and developing the infrastructure needed to support walking and cycling as modes of transportation within our communities.

A few studies have demonstrated that local transportation and planning decisions can have a significant impact on emissions, local air quality, and human health. For example, the California Air Resources Board found that “complete” neighbourhoods (i.e. compact neighbourhoods built around public transit with a variety of services within a five minute walk) can reduce vehicle-related air emissions by up to 20% relative to traditional neighbourhoods (i.e. sprawled neighbourhoods that are separated from public transit, commercial services and recreational facilities). In the City of Atlanta, researchers found that the alternative transportation strategy introduced during the 1996 summer Olympics, which shifted people from their vehicles into public transit, reduced traffic counts by 22.5%, peak ozone levels by almost 28%, and asthma-related hospital admissions among children by 11 to 44% during the Olympics relative to the weeks leading up to the Olympics.

Building-Related Air Pollution

Emission inventories indicate that fuel consumed for space and water heating in buildings and the generation of electricity is also an important source of air pollution in Ontario and Halton. Both sources of emissions are heavily influenced by the size, design and situation of the buildings in our communities.

Small residential buildings built to high energy efficiency standards such as the EnerGuide 80 standard, use 35% less energy (i.e. natural gas and electricity) than buildings built to current day standards. In addition, buildings built to high energy and environmental standards such as the LEED™ Silver, Gold or Platinum standards can reduce energy use in buildings by 35 to 45% relative to similar buildings built to Code. These energy reductions translate into reductions in air pollution and greenhouse gases from the buildings and from electricity generating stations while providing long-term cost savings for residents and/or owners of the buildings.

Building-related air pollution can also be reduced by encouraging the use of alternative energy systems such as co-generation in the commercial, industrial and institutional sector, and renewable energies in the community (e.g. wind generated electricity). Co-generation, which involves the production of both electricity and heat (which can be used to heat or cool a building) has the potential to halve the air pollution and greenhouse gases that can be associated with electricity generation and heating or cooling of buildings when done separately. Renewable energies such as wind, geothermal and deep lake cooling have the potential to produce electricity, or displace the need for electricity or natural gas, while generating almost no air pollution or greenhouse gases.

Air Pollution – Industrial, Commercial and Open Sources

Industrial and open sources are also significant sources of air pollution in Ontario and the Region. While regional and local governments do not have the legislative authority to establish air quality criteria or emissions standards that are applied to pollution sources such as refineries, they have some ability to prevent or reduce the adverse health effects that may be associated with incompatible land uses through the land use planning process. Zoning and set-backs can and are used to separate incompatible land uses. In addition, performance and/or design measures can and are requested through the building permit process to prevent or mitigate the adverse effects that may be associated with the development of new facilities or operations in a community.

Provincial and Regional Objectives

The Ontario Government's new Provincial Policy Statement and the newly revised Regional Official Plan (August 2006) clearly identify the protection of public health and the improvement of air quality as priorities to be addressed through the land use planning process. The two documents also identify objectives and policies for "complete communities", the transportation sector, energy systems, and incompatible land uses, that would, if implemented, mitigate the negative air quality and human health impacts that could be associated with growth in Halton Region. The next stage in the process is to develop the air quality assessment tools and policy instruments that would support the implementation of these objectives.

Assessing Air Quality

In the air quality field, there are a number of different tools that can be used to assess air quality and inform policy development.   Emissions inventories indicate something about the overall contribution of emission sources to regional air quality, but they do not indicate how air pollutants are dispersed once they are released into the air.

Stationary air monitors can provide continuous readings of air pollutants in a particular location and can be used to follow trends in air quality over time. Portable air monitors can be used to monitor air quality in micro-environments such as traffic corridors. Air monitors cannot however identify the sources that contribute to the concentrations measured, nor can they predict how concentrations might be affected by new facilities, new developments, or new policies.

Air quality modelling tools use meteorological information, location, topography, and emissions data to estimate the concentration of different air pollutants across the community. They can also forecast how concentrations of air pollutants might be impacted by new emission sources or by changes in policy. In this way, they can be used to inform land use planning decisions and policy development.

Conclusions

With the growth anticipated for Halton Region over the next 25 years, air quality, human health, and the climate could be negatively impacted by an increase in air emissions associated with buildings, vehicles and workplaces. The Provincial Policy Statement and the Regional Official Plan clearly articulate a number of objectives that would, if successfully implemented, improve air quality and human health and slow climate change.

The Region should develop a community-wide air quality modelling program that can be used to assess air quality and support land use planning decisions, policy development, and health promotion. It should examine the portable air monitoring equipment and/or resources that could be used to assess air quality in micro-environments. In addition, the Region, working in collaboration with the local municipalities, should explore the policy instruments that could be developed to support the development of "complete communities", alternative modes of transportation, energy efficiency, and alternative energies in the Region. The Region should also develop a health promotion campaign to increase public awareness about the link between air quality, human health, climate change, and the built environment, and the actions needed to improve air quality and/or slow climate change.

Glossary of Terms

Air Pollutants and Greenhouse Gases

CH_4	methane – a greenhouse gas
CO_2	carbon dioxide – a greenhouse gas
CO	carbon monoxide – a common air pollutant
DPM	diesel particulate matter – fine and ultra-fine particle emitted from diesel-fuelled vehicles and equipment
NO_2	nitrogen dioxide – a common air pollutant that reacts with VOCs in the atmosphere to produce ground-level ozone
NO_x	nitrogen oxides – includes nitric oxide (NO), NO_2 and N_2O
N_2O	nitrous oxide – a greenhouse gas
O_3	ground-level ozone created in the atmosphere from a reaction between NO_x and VOCs in the presence of sunlight; triggers most of the smog alerts experienced in Ontario in warm weather
$PM_{2.5}$	fine particulate matter – air pollutant associated with both chronic and acute negative health impacts
PM_{10}	coarse particulate matter – includes $PM_{2.5}$ and larger particulates – also associated with chronic and acute negative health effects
VOCs	volatile organic compounds – includes solvents such as benzene and perchloroethylene (the dry-cleaning solvent); emitted from many industrial sources and from gasoline-fuelled equipment and vehicles; also emitted naturally from vegetation such as trees

Organizations and Agencies

CARB	California Air Resources Board
EC	Environment Canada
IPCC	International Panel on Climate Change
OMOE	Ontario Ministry of the Environment
OMA	Ontario Medical Association
OPHA	Ontario Public Health Association
US EPA	United States Environmental Protection Agency
NRC-US	United States National Research Council
WHO	World Health Organization

Units of Measurement

GJ	giga-joules is a measurement of energy
$\mu g/m^3$	micrograms of a chemical per cubic meter of air
ppm	parts per million – x parts of a chemical per million parts air
ppb	parts per billion – x parts of a chemical per billion parts of air
MWh	megawatt-hours – amount of electricity generated or used
VKT	vehicle kilometres travelled
VMT	vehicle miles travelled

Introduction

This report has been prepared to address, in part, goal #9 in the Halton Region Strategic Plan 2004-2006 which states that the Region will:

> "Work to improve air quality in Halton, in cooperation with other orders of government, businesses and the community".

It grows out of action items #9a) which requires the Region to:

> "Define, in conjunction with the development of Healthy Communities principles, a framework of policies leading to improved air quality, to be implemented through the Durable Halton Plan and the resulting Official Plan."

A condensed version of this report, "Durable Halton Plan: Air Quality and Human Health", has been prepared to inform the long-term planning process in Halton Region.

In our society, energy sources such as gasoline, diesel fuel, natural gas, oil and coal, are the most significant contributors of the air pollutants that negatively affect outdoor air quality. They are also the most significant sources of greenhouse gases that contribute to climate change. Our use of energy is greatly influenced by the shape and form of our built environment. Consequently, the built environment can have a profound impact on the quality of outdoor air and the health of our global climate. Within the built environment, buildings, vehicles, electricity generation, and industrial/commercial processes are the primary sources of the common air pollutants.

> Health Canada defines the built environment as the homes, schools, workplaces, parks/recreation centres, business areas and roads that makes up our communities, and includes overhead transmission lines, underground subways, waste disposal sites, and highways that stretch across the country (Srinivasan, 2003).

With buildings, the type and volume of the air pollutants emitted will vary with the size, design and orientation of the building, the quality of the materials used, the energy efficiency of the appliances used within, and the form of energy used for activities such as heating, cooling and lighting. An energy efficient home which uses 40% less energy than a non-efficient home will emit up to 40% less air pollution and 40% fewer greenhouse gases.

The impact of electricity generation on air quality and the climate varies with the form of generation and the technology and fuels employed. Coal-fired power plants, for example, can have a very negative impact upon air quality and the climate while wind-generated electricity emits no air pollutants whatsoever. Air quality can also be affected by industrial processes, commercial operations, mining and agricultural activities.

With vehicles, the type and volume of the air pollutants emitted will vary with the size, weight and design of the vehicle, the fuel used, the number of trips taken, the duration of the trips, and the speed of travel. The built environment can have a profound impact on vehicle-related emissions by determining how far people have to travel for jobs, services and recreation, and the modes to transportation that are available to them. Far less air pollution will be emitted, for example, in a compact community that is well served by public transit, than in a sprawled community in which all travel is done by automobiles. While as a rule, regional and local governments in Canada have little direct influence over building codes, vehicle emission standards, fuel standards, or regulations directed at industrial emissions, they can have a substantial influence on the development patterns, transportation systems, and design of our communities. They can also have some influence over the use and generation of electricity within their communities. In addition, through the land use permitting process, they can exert some influence over industrial and commercial processes that can be associated with negative air quality impacts within their community.

This report summarizes the health impacts that have been associated with poor air quality, discusses the quality of Halton's air and the sources of air pollutants that impact on Halton's air quality. It discusses air quality and the built environment in three broad ways:

1) How air quality is affected by transportation within our communities which is related to the structure and design of our communities;
2) How air quality is impacted by energy use in buildings; and
3) How air quality health concerns can be created by point sources, incompatible land uses and/or the cumulative impacts of multiple emission sources in a localized area.

The report identifies the actions that can be taken to mitigate the negative air quality impacts that can be associated with growth and development.

Current Regional Initiatives that Support Improved Air Quality

This report builds on a number of corporate and community initiatives that have been established or supported by the Region which are expected to have a positive impact on air quality and climate change in a direct or indirect way. For example, the Region:

- Participates in the *Smart Commute Initiative* that strives to reduce vehicle use among Regional employees by promoting carpooling;
- Is applying an *Energy and Environment Management System* (EEMS) to its energy efficiency program to evaluate the air quality and greenhouse gas benefits associated with improvements in the corporation's energy efficiency;
- Is developing alternative energy systems around biogas at its wastewater treatment plant and around methane from its landfill site;
- Facilitates the *Halton Partners for Clean Air* which includes representatives from the Region, local municipalities, community groups and business organizations (MO-09-04; MO-20-06);
- Facilitated the creation of the *Clean Air Plan* for Halton (www.halton.ca/hpca) which identifies actions that organizations and individuals can take to reduce air emissions associated with their own activities (MO-20-06);
- Participates in public awareness campaigns, research projects, and events such as the annual Smog Summit as an active member in the GTA Clean Air Council (MO-65-04; MO-20-06);
- Has become a member of the *Partners for Climate Protection* initiative (MO-11-05);

- Actively promotes alternative forms of transportation through the *Walk On* health promotion program;
- Has developed the R*egional Transportation Master Plan,* which includes a *Transportation Demand Management Program,* a *Cycling and Pedestrian Infrastructure Plan,* a *Transit and HOV Strategy,* and an *Air Quality Management Strategy (*Regional Transportation Master Plan: Strategies, Plans and Guidelines, June 2004. Appendices H, I, J and L);
- Reviews and comments on development applications, subdivision plans, and applications for certificates of approval from the Ontario Ministry of the Environment for industrial and commercial operations in an effort to mitigate negative air quality impacts; and
- Has developed *A Comprehensive Housing Strategy for Halton Region* which should have a positive impact on air quality because apartments, townhouses and smaller houses use less energy and therefore produce less air pollution and fewer greenhouse gases, than larger, detached houses.

A Outdoor Air Quality

Common Air Pollutants

Outdoor air quality can be influenced by many parameters. This report will focus primarily on the common air pollutants that are found in outdoor air in most industrialized societies. These common air pollutants include coarse particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), ground-level ozone, nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO). These air pollutants, called the "criteria air contaminants" by the Ontario Ministry of the Environment, are the ones associated with smog advisories. They are commonly found in the air because they are emitted any time fossil fuels, such as gasoline, diesel, oil, natural gas or coal, are used in vehicles, homes, factories, stores or institutions.

Four of these air pollutants – NO_2, SO_2, CO and ozone – are present in the air as gases. Three of these pollutants are released directly from emission sources such as cars, furnaces and industrial processes, while the fourth - ozone - is created in the air from a reaction between volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. In Ontario, ozone levels are much higher in the warmer months because the reaction that creates ozone requires sunlight and/or heat.

Fine particulate matter ($PM_{2.5}$) refers to solid or liquid particles in the air that are less than 2.5 microns in diameter. $PM_{2.5}$**,** which can be composed of metal fumes, wood smoke, acid mists, dust and pollen, are so small that they can penetrate deep into the lungs where they can be transferred to the bloodstream. $PM_{2.5}$ can be released directly into the air or formed in the atmosphere from other air pollutants such as SO_2 and NO_2.

Hazardous Air Pollutants

This report acknowledges that there is a broader group of air pollutants that can also have a negative impact on human health under certain circumstances. These air pollutants are sometimes called "air toxics" or "hazardous air pollutants". Included in this group are hundreds of substances such as benzene, lead, mercury, and polycyclic aromatic hydrocarbons (PAHs) that can be emitted from a broad array of activities including mining, smelting, manufacturing, electricity generation, waste incineration, driving vehicles, operating construction equipment, and burning wood in appliances such as fireplaces, furnaces and stoves.

B Air Quality and Human Health

Acute Health Impacts

Hundreds of studies conducted in communities around the world have clearly demonstrated that short-term increases in the levels of the common air pollutants are associated with increases in a broad range of acute health effects. Increases in premature deaths (i.e. all non-traumatic deaths), hospital admissions, emergency room visits, respiratory infections, asthma symptoms, school absences, and work day absences, and reductions in lung function have been clearly and consistently linked to short-term increases in the levels of air pollution (OMA, 2005; TPH, 2004; Stieb, 2005; WHO-Europe, 2004; US EPA 2004).

Collectively, these studies have demonstrated that children, the elderly, and those with pre-existing health conditions such as asthma, heart disease, diabetes and chronic obstructive lung disease are at greater risk from air pollution than the general population (Stieb, 2005; WHO-Europe, 2004; US EPA 2004). It is estimated that about 15% of the people living in Halton Region have pre-existing medical conditions that would make them vulnerable to air pollution (Statistics Canada, 2005).

Chronic Health Impacts

A few studies directed at long-term exposures indicate that air pollution may be a risk factor that contributes to the development of chronic diseases as well. Those studies which have followed large populations over time, have found that long-term exposure to particulate matter ($PM_{2.5}$ and/or PM_{10}) is associated with an increase in chronic lung and heart diseases and a reduced life expectancy (US EPA, 2004; Krewski, 2000; Samet, 2000).

For example, in one U.S. study, which followed 1.2 million adults over a 16 year period, it was found that for every 10 µg/m^3 increase in air levels of $PM_{2.5}$:

- Deaths from all causes increased by 4%;
- Deaths from cardiopulmonary disease increased by 6%; and
- Deaths from lung cancer increased by 8% (Pope, 2002).

The researchers concluded that air pollution in some U.S. cities presents a health risk comparable to the risk presented by long-term exposure to second hand smoke (Pope, 2002).

Air Pollution and Children's Health

There is little information on the chronic health effects experienced by children who have prolonged exposure to air pollution. The Children's Health Study is one long-term study that has followed about 6,000 children living in 12 communities in Southern California since 1993. Results from this study suggest that air pollution can have a significant effect on the long-term health of children. For example, it has found:

- A three- to five-fold increase in decreased lung function among adolescents who grew up in communities with high levels of air pollution (i.e. particularly for NO_2, $PM_{2.5}$, PM_{10} and atmospheric acidity) (Gauderman, 2000; Peters, 2004);

- That physically active children living in high ozone communities are up to three times more likely to develop asthma than children living in low ozone communities (McConnell, 2002; Peters, 2004);

- That children living near roadways with high traffic have a greater risk of being diagnosed with asthma (Peters, 2004);

- That children who move to communities with lower levels of particulate matter experience improvements in their lung function growth rates (Peters, 2004); and

- Increases in bronchitis symptoms among asthmatic children exposed to higher annual air levels of $PM_{2.5}$, CO, NO_2 and ozone (McConnell, 2003; OPHA 2005). (*Photo by K. Perrotta)*

Experts in the field indicate that poor childhood lung function is a good indicator for poor health later in life. They report that a small reduction in the average lung function of a population of children can reflect a substantial increase in the number of children who have "abnormally" low lung function, who will be susceptible to lung disease and premature death later in life (WHO, 2005).

Air Pollution's Impact on Reproductive Health & Infants

Over the last decade, a number of studies have examined the impact of air pollution on birth outcomes and reproduction. Birth outcomes are important both as indicators of the health of newborns and infants and as indicators of the individual's health in later life. Low birth weight, intra-uterine growth retardation, and impaired growth in the first years of life are associated with increased mortality and morbidity in childhood and an elevated risk of hypertension, coronary heart disease, and non-insulin-dependent diabetes in adulthood (Sram, 2005).

When a team of scientists conducted a review of the evidence related to air pollution and adverse birth outcomes, they concluded that:

- Infants exposed to higher outdoor levels of airborne particulate matter ($PM_{2.5/10}$) are at increased risk of death from respiratory ailments;

- Air pollution can increase the risk of infants being born with low birth weights; and

- More research should be directed at air pollution's impact on premature births, intra-uterine growth retardation, and birth defects (Sram, 2005).

B1 Estimating Air Pollution Health Outcomes

Health Canada/Environment Canada, the Ontario Medical Association (OMA), Toronto Public Health (TPH), and Clean Air Hamilton have all estimated the impact of air pollution on the health of different populations within Ontario. In each case, these estimates have been developed with:

- Risk factors for each health effect for each air pollutant that have been derived from the best health studies available;
- Health statistics for the populations examined;
- The age and size of the populations examined; and
- The air monitoring data for the communities examined (Stieb, 2005).

For example:

> Air pollution-related premature deaths are estimated by multiplying the risk factor for a particular air pollutant by the mean air level of the pollutant in a particular community by the number of premature deaths experienced in that community.

In each case, these organizations have estimated numbers for health impacts that have been clearly linked to the specific air pollutants. For example, these estimates do not include chronic health impacts among children, nor reproductive effects, because these findings are relatively new.

In each case as well, the estimates represent preventable health outcomes associated with that portion of air pollution that can be attributed to human activities alone. They do not include health outcomes associated with background air pollution resulting from natural sources such as pollen from crops, VOCs from trees, and NO_x from forest fires (DSS, 2005; TPH, 2004).

Air Pollution Health Outcomes in Four Ontario Cities

In 2004, Health Canada and Environment Canada estimated that the five common air pollutants contribute to about 2,900 premature deaths each year in four Ontario cities – Windsor, Hamilton, Toronto and Ottawa. The researchers attributed almost one third of those deaths to short-term exposures to the mix of air pollutants and over two thirds of the deaths to long-term exposures to $PM_{2.5}$ alone. They calculated that the five common air pollutants were responsible for between 7% (in Ottawa) and 10% (in Toronto and Hamilton) of all premature deaths in the four cities (Judek, 2004).

Premature deaths include all deaths that are not attributed to a trauma. Experts in the field maintain that premature deaths do not apply solely to those who "would have died within a few months anyway". They believe that many of those who die prematurely as a result of air pollution die several years before they would have without exposure to air pollution. They also note that in the case of those few infants who are among the premature deaths, life can be shortened by many years (Pengelly, 2004).

Air Pollution Health Outcomes in Ontario

In June 2005, the Ontario Medical Association (OMA) released updated estimates of the health impacts associated with air pollution in Ontario as a whole. It estimated that the five common air pollutants contribute to approximately 5,800 premature deaths, 16,800 hospital admissions, 59,700 emergency room visits, and 29,000,000 minor illness days in Ontario in 2005 (OMA, 2005).

The OMA has valued these health outcomes at approximately $7.8 billion in 2005; about $507 million for institutional care and medication; about $374 million in lost-time for patients and caregivers; $537 million for pain and suffering; and about $6.4 billion for loss of life. These “costs” do not include those associated with visits to doctors’ offices which are expected to be significant (DSS, 2005).

Air Pollution Health Outcomes in Halton Region

The OMA has estimated that air pollution in Halton Region contributes to approximately 190 premature deaths, 540 hospital admissions, 2,010 emergency room visits, and 1 million minor illness days each year (OMA, 2005). It estimates that these health impacts translate into about $17 million in health care costs and almost $13 million in lost-time for patients and caregivers (OMA, 2005).

C Air Pollution – Trends and Emission Sources

C1 Air Quality Trends in Ontario

Some aspects of Ontario’s air quality have improved significantly over the last two and half decades because of provincial acid rain regulations directed at industry and provincial and federal initiatives directed at fuels and vehicle emissions. Air levels of CO, SO_2 and NO_2 have declined steadily and substantially across the province since 1975 (OMOE, 2006). Large urban centres typically experience higher levels of NO_2 because of the larger number of buildings and vehicles using fuel for space heating and transportation (OMOE, 2006).

Ground-level ozone continues to present a challenge across the province. While maximum air levels of ozone have been reduced from about 118 ppb in the early 1970s to 108 ppb in 2004, the annual average levels of ozone have steadily increased. On a province-wide basis, the summer-time average for ozone has increased from about 26 ppb to 32 ppb, while the winter-time average has increased from about 16 ppb to 20 ppb since the early 1970s (OMOE, 2006). It is too early to discern a trend for $PM_{2.5}$ because it has only been monitored consistently across the province since 2003.

C2 Air Quality in Halton

There are currently two air quality monitoring stations being run in Halton Region by the Ontario Ministry of the Environment (OMOE); one in Oakville and one in Burlington.

These stations are used to measure the common air pollutants and their data are used to rate air quality under Ontario's Air Quality Index (AQI) program.

Halton Air Exceeds Canada Wide Standards

As can be seen by Table 1, air levels of ozone in Halton Region commonly exceed the Canada Wide Standard (CWS) for ozone, while air levels of $PM_{2.5}$ frequently exceed the CWS for $PM_{2.5}$. The same can be said for most communities in southern Ontario (OMOE, 2006).

The CWS are not health-based air standards; they reflect technical and economic considerations as well as health evidence. So, while these standards are important benchmarks because the Ontario Government has committed to achieve them by 2010, they do not represent "safe" levels of exposure. In fact, there is a growing body of science which suggests that there may be no level of exposure that is without some negative health effects for both ozone and $PM_{2.5}$ (TPH, 2004; WHO, 2004).

Halton Air Exceeds Health-Based Reference Levels

In 1999, a Federal Provincial Working Group established health-based reference levels for both ozone and $PM_{2.5}$. These reference levels identify the lowest air levels that were, in 1999, clearly and consistently associated with significant increases in premature deaths and/or hospital admissions (NAAQO, 1999; NAAQO, 1999b). As indicated in Table 1, air levels of ozone in Halton Region regularly exceed the health-based reference level for ozone, while air levels of $PM_{2.5}$ frequently exceed the health-based reference level for $PM_{2.5}$ (OMOE, 2006). Once again, the same can be said for most communities in southern Ontario.

C3 Gaseous Air Pollutants Present Health Concerns Also

Air levels of NO_2, SO_2 and CO in Halton Region are well below the ambient air quality criteria (AAQC) established for these air pollutants by the OMOE. Unfortunately, this does not mean that these air pollutants do not present a health concern for Halton residents. Rather, it reflects the fact that these air standards, which were established many years ago, do not reflect the current health literature associated with these air pollutants (TPH, 2004a).

Several studies directed at the gaseous air pollutants alone suggest that they can also have a significant impact on human health at air levels that are common in communities across Canada. In 1998, researchers published an epidemiological study that was directed at the gaseous air pollutants in Canadian cities. They found that air levels of NO_2, SO_2, CO and ozone in eleven Canadian cities were responsible for, on average, 4.1%, 1.4%, 0.9% and 1.8% respectively, of all non-traumatic deaths in those cities, which included Toronto, Hamilton, London, Ottawa and Windsor.

The researchers found that, combined, the four gaseous air pollutants were responsible for 7.7% of all non-traumatic deaths in the eleven cities (Burnett, 1998). These findings demonstrate that while concentrations of these air pollutants are well below the relevant AAQC, they are still associated with a substantial number of severe acute health impacts.

Staff at the OMOE and Health Canada have indicated that the development of new air standards for NO_2, SO_2 and CO are complicated by the interactions between the five common air pollutants. When Health Canada conducted a thorough review of the scientific literature on the five common air pollutants, it found that they exert their effect on human health in an additive or synergistic way that makes it difficult to attribute effects to any one of them independently (Stieb, 2005).

Table 1: Air Monitoring Results Compared to Air Standards and Health Based Reference Levels, Halton Region, Average for Two Monitoring Stations, 2004 (MOE, 2006)

Air Pollutant	Air Monitoring Relative to AAQC, CWS & Health-Based Reference Levels	Ambient Air Quality Criteria (AAQC)	Canada Wide Standards (CWS)	Health Based Reference Level
O_3 ppb	• Exceeds Reference Level more than 50% of time • 3 readings exceed the CWS	80 (24-hour)	65 (8-hour)[1]	20 (1-hour)
NO_2 ppb	• Never exceeds AAQC	100 (24-hour)	NA	NA
CO ppm	• Never exceeds AAAC	13 (8-hour)	NA	NA
SO_2 ppb	• Never exceeds AAQC	100 (24-hour)	NA	NA
$PM_{2.5}$ µg/m³	• Exceeds Reference Level 10% of the time • CWS exceeded 9 times	NA/NA	30 (24-hour)[2]	15 (24-hour)

D Sources of Air Pollution

Air pollution has many sources in an industrialized society. The common air pollutants can be released from mining processes, industrial facilities, commercial processes, electricity generating stations, on-road and off-road vehicles, furnaces, wood-burning appliances (i.e. stoves, fireplaces and furnaces) and lawn mowers.

D1 Transboundary Air Pollution

Because air moves without regard for boundaries, air pollutants emitted in one community can have an impact on communities downwind of it. Because both ozone and $PM_{2.5}$ can take time to form in the atmosphere, both air pollutants can affect communities that are very distant from the original emission sources. This effect is greater for ozone than for $PM_{2.5}$.

In 2005, the OMOE released a report in which it estimated that transboundary air pollution contributes to approximately 2,700 premature deaths and 12,000 hospital admissions each year in Ontario (OMOE, 2005). This report suggests that air pollution originating in the United States is responsible for about one half of the air pollution health impacts experienced by Ontario residents.

Air quality modelling conducted by the OMOE demonstrates that a significant share of the ozone that affects Ontario originates from industrial and transportation sources in the American Mid-West and Ohio Valley regions. It also demonstrates that Ontario is the

[1] 4th highest 8-hour Maximum, 65 ppb
[2] 98th percentile Daily Average, 30 µg/m³ , averaged over 3 years

source of emissions that contribute to ozone levels experienced in jurisdictions downwind such as Quebec, the Maritime provinces, and the New England states (OMOE, 2005). The upwind-downwind nature of air pollution requires cooperation between jurisdictions and action to reduce emissions by all jurisdictions.

With $PM_{2.5}$, the air pollutant that is most clearly linked to air pollution's chronic health impacts, the picture is quite different. While the OMOE found that American sources can have a significant impact on $PM_{2.5}$ levels in many parts of Ontario, it also found that, in the Greater Toronto Area, Ontario emission sources were responsible for more than one half of the $PM_{2.5}$ that is present in the air most of the time (OMOE, 2005). These results suggest that there is much that communities within the GTA can do to improve the air quality experienced by their communities.

With the gaseous air pollutants, NO_2, SO_2 and CO, the impact tends to be more localized with most of the exposure occurring locally.

D2 Emission Sources within Ontario

The provincial and federal governments have estimated emissions for different sectors. These inventories, while based on rough estimates and incomplete data, do provide a broad picture of emission sources. Because air quality in one Region is affected by the emission sources in adjacent Regions, it is useful to examine the emission sources within Ontario as a whole. The Ontario Ministry of the Environment (OMOE) estimates that, across Ontario:

- The **transportation sector** is the most significant source of NO_x emissions in Ontario with the transportation contributing about 64% of all NOx emitted in the province. The transportation sector is also the most significant source of CO and a significant source of VOCs;

- The **industrial sector** is the most significant contributor of SO_x emissions responsible for more than 60% of all SOx emissions in the province;

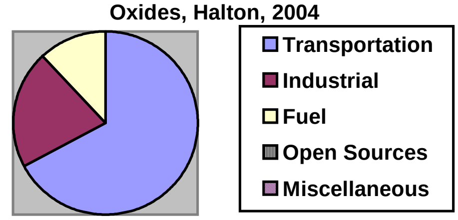
- **Fuel consumption** which includes electricity generation, residential and commercial furnaces, and wood-burning appliances, is an important source of several air pollutants. In 2004, electricity generation was responsible for about 26% of the SOx and 15% of NOx emitted in the province, while residential fuel combustion was responsible for about 13% of VOCs emitted (OMOE, 2006).

D3 Emission Sources in Halton Region

Using data collected and estimated by Environment Canada on the four communities within Halton Region, it appears that:

- The **transportation sector** is the most significant source of NOx and CO and a significant source of VOCs and directly emitted $PM_{2.5}$ within Halton;

Figure 1: Sources of Nitogen Oxides, Halton, 2004



- The **industrial sector** is the most significant contributor of SO_x and VOCs and a significant contributor of directly emitted $PM_{2.5}$ and NO_x within Halton;

- **Fuel consumption** for electricity generation, residential and commercial furnaces, and wood-burning appliances is a significant source of directly emitted $PM_{2.5}$ and an important source of NO_x and CO emissions within Halton;

- **Open sources** such as quarries, road dust, and construction activities are the most significant source of directly emitted PM2.5 in Halton Region; and

- **Miscellaneous** activities such as general solvent use, surface coating (e.g. painting and varnishing), and fuel marketing, are a significant source of VOCs emissions within Halton. (Corr, 2006; OMOE, 2006) (See Appendix 1).

Figure 2: Sources of Carbon Monoxide, Halton, 2004

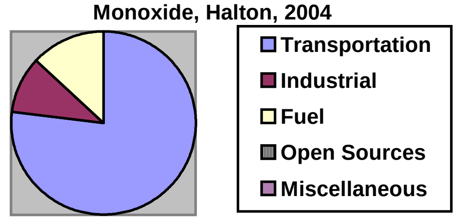


Figure 3: Sources of Volatile Organic Compounds, Halton, 2004

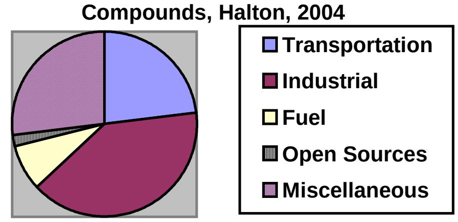


Figure 4: Sources of Sulphur Dioxide, Halton, 2004

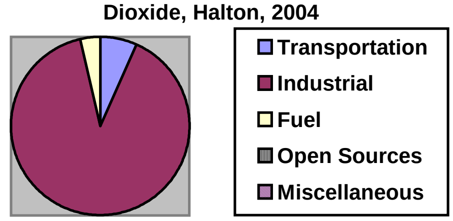
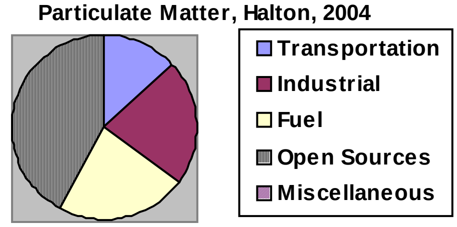


Figure 5: Sources of Fine Particulate Matter, Halton, 2004



When reviewing this list, it is important to remember that VOCs and NO_x are the air pollutants that react to form ground-level ozone, while SO_2 and NO_x can be transformed into $PM_{2.5}$ in the atmosphere (EC, 2006).

E Climate Change and Air Quality

Scientists worldwide have documented a shift in the global climate over the last century. Among most scientists, there is a consensus that this change is due, in most part, to human activities that results in the release of greenhouse gases such as carbon dioxide (CO_2), methane, (CH_4) and nitrous oxide (N_2O) (IPCC, 2001; NRC-US, 2001).

Links between Air Pollution and Climate Change

Air quality and climate change are issues that are linked in several important ways. First of all, climate change is expected to increase the number and duration of warm masses that move into Ontario from the southwest. These warm masses are typically associated with heat waves and smog episodes (Mortsch, 1996; IPCC, 2001). Secondly, the increase in heat waves is expected to be associated with an increased use of electricity for air conditioning that is currently associated with significant emissions of SO_2 and NO_x. Thirdly, air pollution and climate change have many emission sources in common including the transportation sector, electricity generation, oil production and refining, and space and water heating. Lastly, many of the actions needed to improve air quality will produce climate benefits by reducing greenhouse gases, and vice versa.

Other Health Impacts associated with Climate Change

Climate change is expected to have many different impacts on health beyond those associated with air quality. For example, in Canada, climate change is expected to increase the number of heat-related deaths as heat waves become more frequent and more severe. It is also expected to increase the frequency and severity of extreme weather events such as tornados, hurricanes, snowstorms and floods, which can be associated with a variety of negative health impacts.

Climate change is also expected to change the range, intensity and seasonality of insect-borne diseases such as West Nile Virus and Lyme's Disease which could have a significantly negative impact on health in many parts of the world including Canada (Smoyer, 1999; IPCC, 2001). It has also been projected that climate change will affect food and water supplies around the world as crops, fish populations, and livestock respond to shifts in air temperatures, water temperatures, and water supplies. While these changes could have a positive impact on health in those regions of the world where the shift results in increases in food and water supplies, it is expected to have a significantly negative impact on health in those regions of the world that already experience shortages or disruptions in water and food supplies. The shortage in food supplies in other parts of the world is expected to have a negative impact on the cost of food supplies in Canada and the United States (IPCC, 2001).

F Vehicle-Related Air Pollution

As discussed above, the transportation sector is a significant source of air pollutants emitted within Ontario and Halton Region. It is also responsible for about one quarter of total greenhouse gases emitted in this country with cars and trucks responsible for about 70% of those emissions (Canada, 2002). Emissions from the transportation sector can be greatly influenced by transportation and land use planning decisions that are within the influence of local and regional governments.

F1 Traffic-Related Air Pollution Presents a Significant Health Concern

In recent years, a number of health studies have been directed at traffic corridors using vehicle counts and proximity to roadways as indicators of exposure to traffic-related air pollutants. These studies demonstrate the significant impact that on-road vehicles can have on both local air quality and human health. While, in general, these studies demonstrate the need to reduce the volume of traffic through a community, in some cases, they suggest the need to consider proximity to busy roadways when siting sensitive land uses such as schools, hospitals and nursing homes. A few of these traffic corridor studies are highlighted below:

- A cross-sectional study conducted in the Netherlands found that traffic density was significantly associated with **chronic respiratory symptoms among children.** In this study, the traffic density was 80,000 to 125,000 vehicles per day with trucks making up about 10% of the traffic. Cough, wheeze, runny nose and doctor-reported asthma were reported more often for children living within 100 meters from the freeway. These relationships were statistically significant and persisted when corrected for socio-economic factors such as income and education (van Vliet, 1997).

- A study of children in New York State found that **children hospitalized for asthma** were more likely to live within 200 metres of roads with the highest vehicle miles travelled, and/or more likely to live within 200 metres of roads travelled by trucks, than children who were hospitalized for non-respiratory ailments. The researchers found that the increased risk remained when adjusted for socio-economic factors (Lin et al, 2002).

- Researchers in Italy found that the **risk of childhood leukemia** was significantly higher (relative risk of 3.91) among children who lived in homes subjected to high levels of traffic-related air pollution (greater than 10 $\mu g/m^3$ of benzene) than among children who lived in homes subjected to low levels of traffic-related air pollution (less than 0.1 $\mu g/m^3$ of benzene). Concentrations of benzene, derived with dispersion modelling, were used as indicators of exposure (Crosignani, 2004).

- In a Danish study, the researchers found that the **risk of developing cancer** was 1.6 times greater for taxi drivers than for men who were not professional drivers, 1.3 times greater for truck drivers, and 1.4 times greater for unspecified drivers. They found that the differences in risk could not be explained by smoking habits or socio-economic status. They also found that risk of lung cancer increased significantly with increasing duration of employment (Hansen, 1998).

- In England and Wales, researchers found that **death from strokes** was 7% higher among men and 4% higher among women who lived within 200 metres of a main road than it was among those living 1000 metres or more away from a main road. These raised risks (which were statistically significant and adjusted for socioeconomic status) diminished as distance from main roads increased (Maheswaran, 2003).

- In Montreal, researchers found a greater **rate of hospital admissions and premature deaths for respiratory causes among elderly** adults (greater than 60 years in age) whose homes were situated on roads with higher traffic density (greater than 3,160 vehicles during morning peak hours) than among those whose homes were situated on roads with lower traffic density. The risks remained elevated after adjustments for socio-economic status (Smargiassi, 2005).

- In the Netherlands, researchers found that **cardio-pulmonary deaths** among people 55 to 69 years in age were associated with residence near to a major road. This association persisted when corrected for socioeconomic status (Hoek, 2002).

F2 Growth, Transportation & Air Quality

The good news for those concerned about vehicle-related air pollution is that the emissions associated with individual vehicles are expected to drop dramatically over the coming decades as vehicles built to new, more stringent vehicle emission standards, replace existing vehicles. Between 2003 and 2020, the fleet-wide average emission rates for on-road vehicles are expected to drop by about 77% for NO_x, by about 51% for CO, and by about 73% for VOCs (Halton, 2004a).

The extent to which the new vehicle emission rates translate into improvements in air quality will depend upon the number of vehicles in a community and the number of vehicle kilometres travelled (VKT) in a community for day to day errands and commutes associated with work. These latter two factors are greatly influenced by the form of the community (i.e. is it sprawled or compact?), the live/work relationships (i.e. to what extent can people who live in the community work in the community?), the design of neighbourhoods (i.e. can people walk to grocery stores, schools, community centres, parks, and other services?), the availability, convenience and efficiency of alternate modes of transportation such as public transit and cycling, as well as the number of people in the community.

With the growth projected for Halton Region, the number of VKT could increase dramatically over the next 25 years. It has been estimated that the number of vehicles on the road in the Greater Toronto Area (GTA) could increase from 3.7 million in 2000 to 5.6 million in 2031 under a business-as-usual scenario with the growth expected for the GTA. This increase in vehicles is expected to increase the number of VKT per day in the GTA from 157 million to 258 million in the same period (Probe, 2004).

Within the GTA, where there is a high degree of economic integration across Regions, there are two distinct types of travel behaviour that must be addressed when trying to influence the VKT by residents; work-related travel and non-work travel. While Halton Region and the local municipalities within the Region are committed to developing high quality jobs within the Region, there are limits on the ability of any one jurisdiction within the GTA to influence job markets and commuting patterns within the GTA. Therefore, in order to reduce traffic-related air pollution in Halton, actions must be directed towards both commuting patterns across the GTA and travelling patterns within the communities in Halton Region.

There are a number of ways to reduce traffic volume:

- Increasing the use of transit systems by expanding routes, service and infrastructure;
- Decreasing the number of single-occupancy vehicles by encouraging and supporting car pooling;
- Decreasing the number of trips made by encouraging telecommuting (i.e. working from home one day a week);
- Providing infrastructure that supports alternative modes of transportation such as cycling and walking; and
- Requiring the development of “complete” communities that are transit friendly and “walkable”.

F3 Air Quality, Human Health and Reduced Vehicle Use

Several situations have provided researchers with opportunities to assess the air quality and/or health impacts associated with reduced vehicle use.

Reduced Traffic Volume Improves Health

After September 11, 2001, there was a 50% drop in total traffic at the Peace Bridge between Buffalo, New York, and Fort Erie, Ontario, that provided an opportunity to examine how a reduction in traffic flow might impact on human health. When researchers compared the weekly respiratory admissions to the Kaleida Health System and the weekly traffic volumes for the Bridge for 3-months in 2000 and 2001, they found that the drop in total traffic volume in 2001 was strongly correlated with a drop in hospitalizations for respiratory diseases in 2001 (Lwebuga-Mukasa, 2003).

Shift to Transit Reduces Overall Air Emissions

When a Congestion Charging Scheme was introduced to London England in 2003, it was found to increase the use of public transit, reduce traffic congestion, and reduce emissions of air pollutants and greenhouse gases.

The Scheme, which applies to a central area of London that is 22 square miles in size, involves charging each vehicle a single charge of £5.00 (GBP) to enter the charging zone between 7:00 am and 6:30 pm on weekdays. Researchers found that this Scheme:

- Increased the VKT by buses by 20% and taxis by 13% within the charging zone;
- Decreased the VKT by cars by 29% and heavy-duty vehicles by 11% within the charging zone;
- Increased the use of buses by 25%, light-duty vehicles by 8% and heavy-duty vehicles by 5% on the inner ring road that feeds the charging zone; and
- Increased the average daily travelling speed within the charging zone from 19 to 23 km/hour.

The reductions in VKT and increase in speed in the charging zone were estimated to reduce overall emissions of NO_x by 12%, PM_{10} by 11.9% and carbon dioxide (CO_2) by 19.5%. It is noteworthy that the new buses used to meet the increased demand inside the charging zone were equipped with diesel particulate filters (i.e., highly efficient emission control devices) (Beevers, 2004; TPH, 2006).

Shift to Transit Reduces Ozone and Asthma Hospital Admissions

The implementation of an alternative transportation strategy during the 1996 summer Olympics in Atlanta City provided an opportunity for researchers to measure the impact of public transit on air quality and children’s health. The alternative transportation strategy, designed to reduce traffic congestion during the Olympics, aimed to shift individuals from single-occupancy vehicles towards public transit.

The researchers found that during the Olympics, peak weekday traffic counts in Atlanta City were reduced by 22.5 percent when compared to traffic counts in the weeks leading up to the Olympics. This reduction in traffic was strongly associated with a 27.9% reduction in the peak daily ozone levels in the City and an 11 to 44% reduction in the number of children requiring medical attention for acute asthma symptoms in the four medical institutions in the local community (Friedman, 2001).

Factors Affecting Transit Use

The form and configuration of the urban environment is important to both the provision and use of transit. When urban development is compact and located near major transit stations, ridership levels increase (CARB, 1997). A study conducted in Seattle found that nearly all travel was done by car until residential densities reached 13 people per acre. The same study found that employment density levels of 75 employees per acre were necessary before there was a substantial increase in transit and pedestrian travel for work trips (Frank, 2006). Several studies have demonstrated that it is easier to service jobs with transit when they are clustered together along with other services (CARB, 1997).

(Photo from Oakville Transit website.)

F4 Urban Form affects Travel Patterns and Air Quality

Research has demonstrated that the design of urban centres can have a significant impact on outdoor air quality because of the way in which it influences travelling patterns.

Urban Form, Travel Patterns and Air Quality

In 2002, a landmark study prepared by researchers from Rutgers University and Cornell University in collaboration with Smart Growth America, documented the strong correlation between development patterns urban form and air quality.

Using the following four factors as indicators of urban sprawl – residential density, neighbourhood mix of homes, jobs and services, strength of "activity centres" and "downtowns", and accessibility of street network – the researchers were able to demonstrate that communities that ranked high for urban sprawl were characterized by higher rates of vehicle ownership, greater number of miles travelled, decreased number of commuters who walk, bike or take public transit, and greater air levels of ozone. They also experienced increased rates of traffic-related fatalities (Ewing, 2002; TPH, 2006).

When the eight to ten most sprawled cities in the study were compared to the eight to ten most compact cities, the researchers found that:

- 2% of commuters took public transit in sprawled cities compared to 7% in compact communities;
- Maximum air levels of ozone averaged 97.6 ppb in the sprawled cities compared to 68.9 ppb (8-hour average) in the compact cities; and

- On average, there were 15 vehicle-related deaths per 100,000 people in sprawled communities, compared to 9 vehicle-related deaths per 100,000 in the compact cities (Ewing, 2002; TPH, 2006).

Increased "Walkability" Reduces Air Emissions

In a study conducted in King County near Seattle, Washington, which examined "walkability", vehicle emissions per person, and vehicle miles of travel (VMT) per person, it was found that a 5% increase in the walkability of a residential neighbourhood was associated with:

- 32 more minutes of physically active travel per day;
- a 0.23% reduction in Body Mass Index (BMI);
- 6.5% fewer vehicle miles travelled per person;
- 5.6% fewer grams of NO_x emitted per person; and
- 5.5% fewer grams of VOCs emitted per person (Frank, 2006a).

The associations demonstrated in this study continued to be statistically significant after controlling for factors such as gender, education, income, and vehicles per household.

The researchers concluded that, while community walkability has a modest impact on the behaviour of individuals, the total public health impacts could be significant because of the combined health impacts and the number of people affected on a lasting basis. The walkability of the neighbourhoods was assessed using the Walkability Index which measures net residential density, street connectivity (i.e. intersections per square kilometre), land use mix, and retail floor area ratio (Frank, 2006a).

"Complete Communities" Reduce Vehicle Trips

The neo-traditional neighbourhood design or "complete community" is one characterized by interconnected streets, narrow streets, on-street parking, shallow set-backs, shopping on Main Street, and a mixture of land uses, whereas the standard suburban development is characterized by hierarchical streets, wide streets, off-street parking lots, deeper set-backs, strip malls and shopping plazas, and single-use land uses.

A study comparing the two development patterns in the New England states found that residents in complete communities make 50% fewer vehicle trips per day than households in suburban areas. It found that residents in the complete communities were three times as likely to walk to a nearby store, restaurant or park as their suburban counterparts (CARB, 1997).

Complete Communities Reduce Vehicle-Related Air Pollution

The California Air Resources Board (CARB) has estimated the vehicle-related air pollution associated with several "complete communities" when compared to their suburban counterparts.

In "Uptown District", San Diego, a new neighbourhood of 310 housing units was developed with a residential density of 43 dwelling units per acre, compared to the 12 units per acre average in surrounding neighbourhoods. It was developed with a community centre, interior courtyards, pedestrian and bike paths, within a 2 to 3 minute walk to the supermarket. It was well serviced by transit. CARB estimates that vehicle emissions from this community would be 20% less than those associated with the average suburban community with the same number of residents. On an annual basis, this 20% reduction translates into 2.75 tons of smog-forming air pollutants (CARB, 1997).

"The Crossings", Mountain View, is a compact, mixed-use neighbourhood south of San Francisco which includes 540 single and multi-family housing units, a supermarket, several retail shops, and a daycare centre clustered near a commuter rail station. With residential density of 30 units per acre, the neighbourhood was developed in a "neo" traditional form with narrow interconnected streets, front porches, and rear garages. It takes residents only a few minutes to walk to the stores, park or train station. CARB estimates that the design of this neighhourhood will reduce vehicle emissions by at least 10% relative to an average suburban neighbourhood with the same number of residents. The 10% reduction represents about 3 tons of smog-forming air pollutants on an annual basis (CARB, 1997).

Factors influencing Walking and Cycling Patterns

One researcher has suggested that at a neighbourhood level, five elements of the built environment impact upon the travel behaviour of its residents:

- Density of development which can be measured by number of people or jobs per acre;
- Land use mix which can be measured by distance from house to nearest store or a dissimilarity index;
- Street connectivity which can be measured by intersections per square mile or average block length;
- Street scale which can be measured by the ratio of building heights to street width or average distance from street to buildings;
- Aesthetic qualities which capture the design of buildings, landscaping, presence of trees and shade, and "sense of place" (Handy, 2002). *(Photo from Smart Growth America website.)*

Studies directed at walking patterns indicate that accessibility, safety and attractiveness are factors which influence the walking patterns of people in a community. One U.S. study found that 70% of residents will routinely walk 500 feet, 40% are willing to walk 1,000 feet and only 10% are willing to walk 2,000 feet or more during their normal daily routines. This study found that people will walk further if the walking environment is pleasant and interesting (CARB, 1997).

A study conducted in King County found that the land uses most strongly linked to the percentage of walking trips in the Seattle area were educational facilities, commercial office buildings, restaurants, taverns, and neighourhood retail stores, with grocery stores and civic centres coming next**.** The number of retail outlets, rather than the total square footage of retail space, was found to be important in the decision about whether to walk for non-work purposes (King Country, 2005; Frank, 2006).

The King County study also found that the odds of walking increased by 20% for each additional park and 21% for each additional educational facility within a one kilometre distance from residential locations. Another study found that proximity to open space, particularly larger parks with more amenities, was strongly associated with the physical activity of the residents (King Country, 2005; Frank, 2006; Giles-Corti, 2005).

In communities that provide safe and direct bicycle routes, bicycling can become an attractive mode of transportation. In the City of Davis, where a high-quality, interconnected network of bicycle and pedestrian paths have been provided, it was found that 22% of employed residents and 43% of students surveyed ride their bicycles to school or work respectively. This compares to the 2% bicycling rate for the nearby region of Sacramento (CARB, 1997).

F6 Halton Region – Indicators of Urban Form and Travel Patterns

Urban Density in Halton

When the Ontario Government assessed the residential and job density of the "urban growth centres" in Halton Region in 2001, it found that:

- Burlington had, on average, 27.1 residents and 17.1 jobs per hectare;
- Milton had, on average, 26.2 residents and 8.1 jobs per hectare with a population of 21,900 (By 2004, the population was expected to approach 50,000); and
- Midtown Oakville had, on average, 22.2 residents and 11.9 jobs per hectare.

Commuting Distances in Halton

Halton Region has more people travelling longer distances to work each day than other large municipalities in Canada. When the FCM compared Canada's 20 largest municipalities and urban regions for travelling patterns, it found that, on average, residents in Halton commute longer distances than residents in the other 19 Canadian communities. Halton residents commute, on average, 16.6 kilometres per day (km/day) while residents in 17 of the other municipal areas commute less than 9 km/day. Commuting patterns in Peel and York Regions were found to be very similar to patterns in Halton Region (FCM, 2004).

The FCM also found that more residents in Halton Region commute longer distances than residents in the other 19 communities. In Halton Region, more than 20% of residents commute greater than 30 km/day to work while between 2 and 15% of residents in the other communities travel greater than 30 km/day to work (FCM, 2004).

Place of Work for Halton Residents

The commuting distances for Halton Region reflect the fact that so many people within Halton work outside of the Region. The Census Data for 2001 indicate that about 36%

of the labour force in Halton Region work within their own communities, while 55% of the people in the labour force in Ontario as a whole work within their own communities. It appears that about 59% of the people in Halton's labour force work outside of their communities; about 9% within Halton Region and about 50% outside of the Region (Census, 2001).

Modes of Transportation - Commuting

The FCM study found that private vehicles were the dominant form of transportation for commuters across the country with close to 80% of all commuting trips being made in private vehicles in all of the communities except Vancouver, Ottawa and Toronto where public transit was the mode used for between 20 and 35% of commuting trips. In Halton, the FCM reported that public transit is used for about 8% of commuting trips (FCM, 2004).

Within Halton Region, reliance on public transit for work day commutes varies significantly with 13% of commuters in Oakville travelling by public transit and only 3% of commuters in Milton and Halton Hills travelling by public transit (Census, 2001)(see Table 2 below).

The FCM study also found that, among the 20 Canadian communities, Halton, York and Peel Regions had the lowest proportion of residents walking or cycling to work. On average, 8% of commuters in the 20 communities walk or cycle to work each day, while only 4% in Halton Region do so. The communities across Canada with the highest proportion of walking or cycling commuters were Vancouver, where about 17% of people walk or cycle, and Kingston, where about 15% walk or cycle (FCM, 2004).

Table 2: Place of Work & Commuting Patterns, Halton Region (Census Data, 2001)

Place of Work & Commuting Patterns	Oakville	Burlington	Milton	Halton Hills
% Working in community in which they live	34%	39%	41%	30%
% Working in different community within Halton	5%	15%	12%	9%
% Working in different community outside Halton	51%	36%	37%	50%
% Commuting by Public Transit	13%	8%	3%	3%
% Commuting by Car/Truck/Van	82%	87%	91%	91%
% Commuting on Foot	3%	4%	5%	5%
% Commuting on Bicycle	<1%	<1%	<1%	<1%

Note: Numbers have been rounded to nearest whole number

F7 Potential Impact of Development Patterns on Vehicle-Related Emissions in Halton

Two-Vehicle Households Scenario

The impact of planning decisions on vehicle-related air pollutants and greenhouse gases can be illustrated in rough terms by making rough estimates using some common assumptions[3].

If the Region accommodates an additional 400,000 people in communities that require two vehicles per household, the NO_x emissions associated with new growth could be about 4,729 tonnes NO_x per year. These emissions are equivalent to those associated with four 680-megawatt (MW) natural gas-fired power plants operating full-out for a year (see Appendix 2 for calculations). While these emissions would not all be emitted within Halton Region, they would all be released at ground-level where they could have a substantial impact on those who travel along and/or live or work beside the routes upon which they would be released.

Table 3: Annual CO_2 Emissions, Individual Vehicles, 20,000 km/year (Canada, 2002)	
Gasoline Hybrid	2 tonnes
Mid-Sized Sedan	4 tonnes
Sports Utility Vehicle (SUV)	6 tonnes

This two-vehicle scenario would also be associated with between 360,800 and 1,082,000 tonnes of greenhouse gases per year, with the low estimate representing a scenario in which all of those vehicles are gasoline hybrids and the high estimate representing a scenario in which all of those vehicles are sports utility vehicles (SUVs) (see Appendix 2).

One-Vehicle Households Scenario

If, however, the Region can accommodate these 400,000 people in communities that only require one vehicle per household by shifting one commuter to public transit or a local job, and reducing errand-related vehicle trips by 50% by making neighbourhoods "walkable" and bicycle-friendly, vehicle-related NO_x emissions could be reduced to about 2,309 tonnes per year -- equivalent to two natural gas-fired power plants (see Appendix 2). This scenario would be also cut greenhouse gas emissions by almost half as well (see Appendix 2).

F8 Halton Working to Reduce Vehicle Use

Halton Region has recognized the need to reduce the number of single passenger vehicles on the roads in Halton Region and is actively working on programs within the Region and in partnership with other agencies across the GTA to rectify the situation.

Halton Transportation Master Plan

Over a two year period, Halton Region developed a comprehensive Transportation Master Plan which includes components directed at transportation demand

[3] Assuming that: the additional 400,000 people proposed for Halton Region between 2001 and 2031 are all accommodated in dwellings that house, on average, three people each; all of those who commute outside their communities commute 50 km/day; those who do errands by vehicle travel 5 km/day; and applying current day emission rates. See Appendix 2 for calculations.

management, cycling and pedestrian infrastructure, transit and high occupancy vehicle networks, intelligent transportation systems, and transportation network improvement (Halton, 2004).

Adopted in June 2004, the Plan also includes an Air Quality Management Strategy that includes recommendations directed at promoting public transit, transportation demand management, and on-street and off-street bike paths to reduce vehicle kilometres travelled across the Region. It also identifies the need to implement street sweeping and flushing in industrial and commercial areas to minimize road dust that contribute to air levels of $PM_{2.5}$ along traffic corridors (Halton, 2004).

Smart Commute Halton

Halton Region is actively working to reduce the vehicle kilometres travelled on the road in Halton Region through the Smart Commute Initiative. The Smart Commute Initiative, undertaken in partnership with the Regions of Peel, York and Durham, and the Cities of Toronto, Hamilton and Mississauga, is working to establish local Transportation Management Associations (TMA). The TMAs are composed of employers that work together to provide employees with sustainable transportation options such as carpooling. The Smart Commute Halton TMA has begun by establishing a Transportation Demand Management program at the Halton Regional Centre for its employees. This program, which was launched in June 2006, is being used as an example for other regional facilities, local municipalities, and employers within Halton Region (Halton, 2006).

G Building-Related Air Pollution

With the growth expected in the Region, it can be expected that building-related air pollution will increase as well. Building-related air pollution includes emissions associated with the generation of electricity and emissions associated with the heating and cooling of air and water used in buildings.

Electricity Generation & Air Quality

A significant portion of the electricity in Ontario is currently generated in coal-fired generating stations. As discussed earlier in this report, these coal plants are responsible for a significant share of the SO_x and NO_x emissions in Ontario. It has been estimated that the air pollution from these five plants contribute to approximately 668 premature deaths and 928 hospital admissions in Ontario each year (DSS, 2005a). They are also one of the most significant sources of greenhouse gases in Ontario (OPHA, 2002). The Ontario Government has made a commitment to phase out the use of these coal plants but it can not do so until the electricity generated in them is replaced by other sources or displaced by reductions in electricity demand. (*Photo by Peter Lusetyk.)*

The Pembina Institute has estimated that electricity consumption in Ontario could be reduced by 40% by 2020 with policies that encourage the use of energy efficient technologies, co-generation, and a shift from electricity to gas for home heating. It has also estimated that electricity generated from renewable sources such as wind, new hydro, and biomass (e.g. use of methane from municipal landfill sites) could provide about 31% of electricity demand in 2020 under an energy efficient scenario (Pembina, 2004).

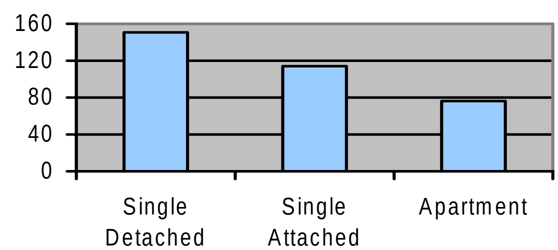
Direct Fuel Consumption in Buildings & Air Quality

As mentioned earlier in this report, fuel consumed in furnaces, fireplaces, barbeques, and lawn care equipment can have a greater impact on local air quality than may be expected. Some of these devices can emit greater volumes of air pollutants per hour of operation than cars because they have not been built to high emission standards and are not equipped with emission control devices. In addition, because these sources emit air pollutants at ground level, they may not be dispersed as widely as air pollutants emitted from tall stacks. Fuel consumption in buildings is also an important source of greenhouse gases.

G1 Energy Efficiency, Electricity Use & Fuel Consumption

Electricity use and fuel consumption are both influenced by the number of buildings in a community, the size of those buildings, the materials, design and construction of the buildings, and the activities being conducted inside of them. For example, space heating requirements for apartments and row houses are significantly lower than for detached homes, because of their smaller size and because heat loss is reduced through shared walls (ICF, 2006)(see Figure 6).

Figure 6: Residential Energy Use, Types of Housing, 2003, GJ/year (ICF, 2006)



It is possible that local and regional governments can have a substantial impact on electricity use and fuel consumption within their communities by encouraging energy conservation and energy efficiency with building standards that are applied to residential and commercial buildings through the land use planning process. By reducing the demand for electricity and fuel consumption associated with new buildings, local and regional governments can minimize the air quality and climate change impacts associated with these new buildings, while producing long-term energy savings for future residents.

LEED Building Standard for Commercial Buildings

There are a number of new technologies and practices that can be applied to buildings to reduce energy use which can produce benefits for outdoor air quality. A few rating systems have been developed to evaluate and encourage the new technologies and practices.

The Leadership in Energy and Environmental Design (LEED™) Standard, developed by the U.S. Green Building Council has been licensed to the Canada Green Building Council, a non-profit corporation, for implementation in Canada. The Canadian version of LEED™ provides a comprehensive list of guidelines to improve the energy and environmental performance of commercial buildings using proven principles, technology, and materials that are aligned with Canadian standards and appropriate to Canadian weather conditions (Waterloo, 2005).

The LEED™ program can be used to evaluate and rate the energy and environmental performance of a building from a whole building perspective. Points are awarded for meeting specific performance criteria that are beyond the minimum requirements contained in the Building Code. Points are awarded for the sustainability of the site in terms of selection and use, the water efficiency of the building, the energy efficiency of the building, the sustainability of the materials used in the building, the quality of the indoor environment created, and the innovation of the design of the building. The energy efficiency characteristics, which can include the use of renewable energy sources such as passive solar and geothermal systems, are the ones that have the most impact on outdoor air quality. Under this category, buildings can receive up to 10 points for using 25% to 64% less energy than a similar building built to minimum codes and energy standards (Waterloo, 2005).

Under LEED™, buildings can be rated as Certified (26 to 35 points), Silver (33 to 38 points), Gold (39 to 51 points) and Platinum (52 to 70 points). The LEED™ program guarantees that energy efficiency in rated buildings will be at least 25% greater than in similar buildings built to Code, although in many cases it will be 35 to 45% greater (Waterloo, 2005).

The Region of Waterloo and the Cities of Calgary, Kingston and Victoria have adopted a LEED™ Silver as a minimum sustainable design and construction standard for their new corporate facilities, while the City of Vancouver and Public Works and Government Services Canada have set the goal of LEED™ Gold for all new facilities starting in 2005 (Waterloo, 2005).

Building Standards for Residential Buildings and Sites

There are a few rating systems that can be applied to small residential buildings and sites; R-2000, Energy Star and LEED for Homes.

The R-2000 energy rating system is a voluntary national Canadian standard developed by Natural Resources Canada (NRCan) that applies to new, single-family homes. It applies primarily to energy efficiency but also touches on indoor air quality and the use of recycled materials. An R-2000 home typically uses 40% less energy than other new homes built to the minimum requirements of the Building Code. Builders must be trained in R-2000 to meet the standard and houses must be evaluated by a licensed R-2000 evaluator before, during and after construction (Toronto, 2006).

The Energy Star for New Homes is also a program of NRCan. It applies to all low-rise, residential buildings regulated by the Ontario Building Code. This program's focus is almost exclusively on energy rating. New homes that meet the Energy Star standard will be 40% more efficient than homes built to minimum building code standards. This program is a new program that has been piloted over the last two years. To be Energy

Star quality, a new home must score 78 on the EnerGuide for new houses scale (Toronto, 2006). In May 2006, the Town of East Gwillimbury in Ontario announced that it would be requesting developers of residential developments of ten or more units to construct them to Energy Star qualifications. This policy was adopted by Town Council on March 20, 2006 (Gwillimbury, 2006).

The LEED for Homes is a comprehensive standard that is still being developed by the U.S. Green Building Council that will apply to a broad range of environmental factors as well as energy consumption (Toronto, 2006).

Energy Efficiency & Ontario's Building Code

The new Ontario Building Code, filed on June 28, 2006, significantly improves the energy efficiency for "non-residential and larger residential buildings" and small residential buildings.

According to officials at the Ontario Ministry of Municipal Affairs and Housing (MMAH), the new Ontario Building Code, which came into effect on December 31st, 2006, will reduce energy used in "non-residential and large residential buildings" by 25% relative to existing requirements when it comes into full effect in 2012. It should also reduce energy use in new small residential buildings by 35% over the existing requirements when it comes into full effect in 2012 (MMAH, 2006). The new requirements for residential buildings, which will be phased in between December 31st, 2006 and December 31st, 2011, will achieve the EnerGuide 80 level by 2012; a rating that would be given to a residential building built to the R-2000 or Energy Star for New Homes rating (MMAH, 2006).

One of the criticisms of the new Ontario Building Code is the long implementation period provided for the full introduction of the new standards. With the fast pace of development in Halton Region, the long implementation period for the next building standards represents a lost opportunity that will have impacts on air quality in the Region for many years to come. It may be worthwhile to see if there are ways that the Region could accelerate the implementation of the new Ontario Building Code to all types of buildings and encourage the application of the LEED™ standards to large, non-residential buildings.

Using the Planning Process to Encourage Energy Efficiency

While many emission sources are beyond the regulatory control of local or regional governments, the emissions associated with buildings within a community can be influenced by local and regional governments through the land use planning process. A few cities around the world, including Chicago, Santa Monica, and New York, have developed their own building codes to reduce the energy-related and environmental impacts associated with buildings in their communities. In Ontario, municipalities do not, as a rule, have the authority to establish building codes that require higher standards than those which exist in the Ontario Building Code for privately owned buildings in their communities. However, they may be able to influence building standards under certain circumstances (Toronto, 2006).

In Vancouver, for example, proponents are pressed to achieve higher standards (e.g. a LEED™ Gold rating) for commercial buildings when they apply for rezoning and/or an

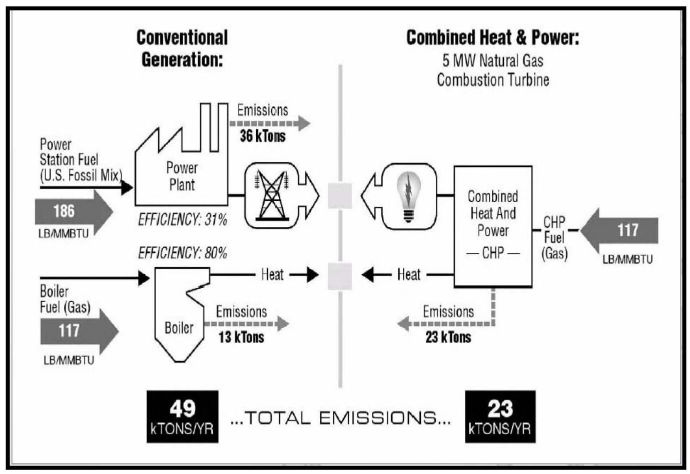
Official Plan Amendment. In addition, Vancouver and Chicago have introduced a type of discretionary zoning where developments are entitled to greater densities over a certain threshold provided that a number of public benefits are met. Using this approach, these cities have secured environmental improvements such as "green roofs" as a form of public benefit in some circumstances (Toronto, 2006). It is possible that practices such as these could be used to encourage higher energy efficiency standards for buildings constructed in Halton Region.

G2 Co-generation, District Energy and Renewable Energies

With the deregulation of the electricity sector in Ontario, there are opportunities for local and regional governments to encourage district energy systems, combined heat and power, and renewable energies through the land use planning process as well.

Co-generation or Combined Heat and Power Systems

Co-generation or a combined heat and power (CHP) system is one in which one energy source is used to produce two forms of useable energy. For example, the waste heat from an industrial process can be captured to generate electricity. Or in another case, the waste heat from an electricity generator can be used for heating or cooling air or water in an adjacent building. These CHP systems can be used to address the needs of one building or complex or attached to a district energy system. (*Diagram from EPA CHP Partnership, Kim Crossman, Aug 2005)*



CHP systems can produce significant reductions in emissions of air pollutants and greenhouse gases while simultaneously cutting fuel costs because they provide two useable forms of energy with the same fuel typically used to provide only one useable form of energy. For example, where a coal-fired power plant in Ontario converts about 35% of the energy in its fuel to useable energy (i.e. electricity), a CHP system built around a high efficiency generator, can convert about 85% of the energy in its fuel into useable energy (i.e. electricity and heat for heating or cooling air or water (Torrie, 1999; Klein, 2001).

Staff at Environment Canada have estimated that CHP systems could provide over 20% of the Canada electricity and heating needs while producing major reductions in air pollution and greenhouse gases (Klein, 2001).

District Energy Systems

A district energy system is a system in which boilers, furnaces and air conditioners in individual buildings have been replaced with a central heating or cooling plant that heats or cools a number of buildings with hot water/steam and/or cooled water that is distributed through buried pipes. They can operate on a variety of fuels and energy sources. They can be based on methane from landfill sites, waste heat from an industrial site, geothermal energy, or deep lake cooling technologies. These systems can be very flexible, allowing new suppliers of hot or cold water to be added over time and allowing expansion of the network over time. While they are most economical in high density areas, low density areas can be serviced economically if high and low density areas are planned together as part of a single project (Torrie, 1999).

There are over 160 district energy systems operating in Canada with projects in Toronto, Sudbury, Hamilton and Windsor. A CANMET study, which examined 75 Canadian municipalities, estimates that district energy systems could provide 23% of all of the space and water heating demand in all 75 of those communities (Torrie, 1999). If district energy systems and/or CHP are to be developed, local and regional governments must identify the opportunities for their development and remove the impediments to their development.

Renewable Energies

The Pembina Institute estimates that wind generated electricity could provide about 18% of the electricity needed in 2020 under a high energy efficiency future (or 18,400 GWh). It also estimates that new hydro generated electricity could provide about 8% of Ontario's electricity (8,800 GWh) in 2020 while biomass generated electricity could provide about 5% of the province's needs in 2020 (5,600 GWh)(Pembina, 2004).

With land use planning policies, local and regional governments can encourage the development of renewable energies by identifying and preserving locations that are suitable for renewable energy projects, reducing impediments to their development, and incenting their development where possible. *(Photo by Quentin Chiotti.)*

H Air Pollution – Industrial, Commercial & Open Sources, and Greenspace

H1 Industrial, Commercial and Open Sources

While there is a desire to encourage mixed land uses within communities for a variety of reasons, there is also a need to ensure that incompatible land uses are adequately separated to protect public health and ensure harmonious relationships within the community.

While local and regional governments do not have the legislative authority to establish air quality criteria or emissions standards for emission sources such as oil refineries, automobile plants, aggregate quarries, truck depots or dry-cleaners, they have some ability to prevent or reduce the negative air pollution health impacts that may be associated with these facilities through the land use planning process.

In some cases, localized air quality impacts associated with either the common air pollutants or hazardous air pollutants can be avoided by providing adequate distance or setbacks between emission sources and nearby sensitive land uses such as schools or residential neighbourhoods, or hospitals. Other times, negative impacts can be avoided or reduced with project design changes or mitigation measures that are required before permitting a new facility.

The California Air Resources Board (CARB) has examined the health risks associated with a number of common land uses and recommended guidelines to be applied to those land uses to avoid or mitigate negative health impacts. A few of these land uses are examined below to identify the health concerns that can be associated with some land uses and the set back that can be employed to avoid or mitigate health concerns.

Schools, Air Quality & Busy Roadways

As discussed above, many traffic corridor studies have indicated that busy roadways can present an increased health risk for those who live or work in close proximity to them. When an air monitoring study was conducted for the Los Angeles Unified School District, researchers found that concentrations of PM_{10} were 5.78 to 14.58 $\mu g/m^3$ (24-hour average) higher than ambient air levels for the community at four schools that were located close to busy roads (i.e. up to 225,000 vehicles per day). While recognizing that air levels can vary depending upon meteorology and topography, they recommended that schools be sited at least 200 meters from high volume highways and roadways. They also identified the application of high efficiency filters to the ventilation systems of schools that are currently situated in high traffic locations (Korenstein & Piazza, 2002).

Sensitive Receptors, Air Quality & Busy Roadways

When CARB reviewed two air monitoring studies that were conducted along roadways for air pollutants, it found that while concentrations of air pollutants remained elevated 1,000 feet from highways, the concentrations dropped significantly within the first 500 feet (CARB, 2005). CARB noted that the health risks associated with roadways vary with the volume of traffic, the number of heavy-duty diesel trucks, the distance to neighbouring properties, and the dominant direction of the wind. It found, for example, that a highway travelled by 10,000 trucks per day, presents an elevated cancer risk for people located within 300 feet of the highway on the downwind side of the highway (CARB, 2005). On the basis of this analysis CARB recommended that agencies avoid siting new sensitive land uses such as schools, day cares, homes, playgrounds, and medical facilities within 500 feet of a highway or urban road travelled by 100,000 vehicles per day, or within 1,000 feet of a rural road travelled by 50,000 vehicles per day (CARB, 2005).

Distribution Centres, Trucks and Air Quality

Distribution centres or warehouses are facilities that serve as a distribution point for the transfer of goods. These centres can involve trucks, transport refrigeration units, trailers, warehouses and shipping containers and other equipment with diesel-fuelled engines. While regulations established by the federal government will significantly reduce emissions from heavy-duty diesel trucks in the coming years, in the meantime, these vehicles can emit significant quantities of $PM_{2.5}$, ultra-fine particles, NO_x, and other air toxics at ground level. While the air quality impacts associated with distribution centres will vary with the number of trucks and engines operated, the age of those vehicles and engines, the distance to neighbouring properties, and the meteorology (e.g. wind direction), CARB estimated that cancer health risks could be elevated up to 800 to 3,300 feet away from the distribution centre if 40 transport refrigeration units were being loaded or unloaded for an hour each, 12-hours per day, seven days a week. CARB estimates that the risks would be comparable if 100 non-refrigerated trucks per day were processed at a distribution facility (CARB, 2005).

Air modelling analysis conducted on distribution centres by the South Coast Air Quality Management District found that diesel PM emissions drops off by about 80% at approximately 1,000 feet from the distribution centre. On the basis of both studies, CARB recommends that new sensitive land uses be sited at least 1,000 feet away from distribution centres that handle 100 trucks per day or 40 TRUs per day (CARB, 2005).

Railway Yards, Trains and Air Quality

When CARB assessed the health risks associated with Roseville Rail Yard in Northern California, it found that the rail yard, which handles over 30,000 locomotives per year, is the source of about 25 tons of diesel particulate matter (DPM) per year. It found that about 50% of those emissions were associated with moving trains while idling trains were responsible for about 45% of them. CARB concluded that the DPM emissions in this situation presented a substantially elevated risk of premature death, respiratory illness and cancer for individuals living or working within 10 to 40 acres of the rail yard (CARB, 2005).

While the health risks associated with other rail yards will vary depending upon the number of trains handled, the size of those trains, the meteorological conditions, the topography, and the distance to neighbouring properties, CARB recommends that governments avoid siting new sensitive land uses within 1,000 feet of a major service and maintenance rail yard and consider applying siting limitations and mitigation approaches within one mile of a rail yard (CARB, 2005).

H2 Cumulative Impacts

Working with the Provincial Government

When the Ontario Ministry of the Environment (OMOE) reviews the impacts of air pollutants from new or existing point sources such as industrial facilities, it assesses the impact of the facility against the point of impingement standards and/or ambient air quality criteria at the fence line of the property. It does not consider the cumulative impacts associated with a variety of contaminants from a multitude of emission sources within the community. There are reasons for this. It can be extremely complicated to assess the cumulative health impacts associated with a wide variety of pollutants that may be present in the environment from a variety of sources. It can also be difficult to address cumulative impacts with existing regulatory mechanisms. However, cumulative impacts continue to be a concern for public health units in those situations where localized neighbourhoods are subjected to a variety of different air contaminants from a number of different sources.

In Ontario, air pollutants from points sources are regulated with a new regulation, Regulation 419 “Air Pollution – Local Air Quality”, under the *Environmental Protection Act.* Passed in 2005, this Regulation which replaced Regulation 346, applies to hundreds of air pollutants, including a few of the common air contaminants, when they are released from point sources such as industrial facilities. It requires the preparation of emission summaries, the modelling of emissions with updated air quality models, and the application of new and revised ambient air quality criteria (AAQC) and/or point of impingement guidelines to new and existing facilities on a timetable that stretches over the next two decades.

While the Regulation does not require proponents to consider cumulative impacts or background concentrations when assessing their emissions, it does provide the Ministry with the authority to consider background concentrations when assessing applications from proponents (OMOE, 2006a). The Ministry of the Environment has indicated that it will consider whether “background exposures” should be considered when assessing applications from proponents when public health units identify the need to do so (OMOE, 2006a). Public health units cannot however, identify “stressed airsheds” without air quality modelling that assesses air quality across the community.

H3 Greenspace

Greenspace serves many different purposes and provides a number of public health benefits. From an air quality perspective, greenspace provides relief from emissions associated with human activities. It can be used to reduce the overall loading of an airshed with air pollutants from human activities. Greenspace can also be used to separate emission sources such as quarries or roadways from sensitive land uses such as schools and residential buildings.

Trees and vegetation do release VOCs during the growing season and do absorb some air pollutants from the air. It is also likely that trees and vegetation trap PM_{10} and $PM_{2.5}$, thereby preventing these particles from becoming re-entrained in the air. They also capture CO_2 and serve as “sinks” for greenhouse gases, thus helping to retard climate change. By providing shade, trees and vegetation also help to mitigate the negative impacts associated with climate change by reducing the “heat island effect” that occurs when pavement, concrete, and buildings in urban areas absorb heat thereby heating the surrounding air both day and night.

I Provincial Policy Statement & Region’s Official Plan

I1 Provincial Policy Statement and Air Quality

Policy Statement, Public Health and Air Quality

The new Provincial Policy Statement, released under Section 3 of the Planning Act in March 2005, clearly requires the protection of human health and the improvement of air quality. Section 1.1.1 c) maintains that Healthy Communities are sustained by:

> “Avoiding development and land use patterns which may cause environmental or public health and safety concerns”,

while Section 1.1.3.2 a) 3 states that:

> "land use patterns within settlement areas shall be based on densities and a mix of land use which minimize negative impacts to air quality and climate change, and promote energy efficiency…".

Policy Statement, Air Quality – Transportation and Energy

Section 1.8 of the Policy Statement, dedicated entirely to air quality and energy issues, identifies compact urban form, alternative modes of transportation, "walkability" of neighbourhoods, energy efficiency and alternative energy systems as land use planning issues that directly impact on air quality and climate change. Section 1.8.1 states that:

> "Planning authorities shall support energy efficiency and improved air quality through land use and development patterns which:
>
> a) Promote compact form and structure of nodes and corridors;
> b) Promote the use of public transit and other alternative transportation modes in and between residential, employment and other areas where these exist or are to be developed;
> c) Focus major employment, commercial and other travel-intensive land uses in sites which are well served by public transit….;
> d) Improve the mix of employment and housing uses to shorten commute journeys and decrease transportation congestion; and
> e) Promote design and orientation which maximizes the use of alternative or renewable energy, such as solar and wind energy, and the mitigating effects of vegetation."

Section 1.8.2 emphasizes the need to develop renewable and alternative energy systems where feasible:

> "Increased energy supply should be promoted by providing opportunities for energy generation facilities to accommodate current and projected needs, and the use of renewable energy systems and alternative energy systems where feasible."

Policy Statement, Energy Efficiency and Alternative Energy Systems

The Policy Statement links prosperity to the proper management of energy supplies and also encourages energy conservation and the development of renewable and alternative energy systems. Sections 1.7.1 h) state that long-term economic prosperity should be supported by:

> "Providing opportunities for increased energy generation, supply and conservation, including alternative energy systems and renewable energy systems".

Policy Statement and Alternative Modes of Transportation

The Policy Statement emphasizes the need for planning authorities to promote "walkable" communities that are well served by public transit and alternate modes of transportation. Section 1.5a) states that active communities should be promoted by:

> "….planning public streets, spaces and facilities to be safe, meet the needs of pedestrians, and facilitate pedestrian and non-motorized movement, included but not limited to, walking and cycling",

while Sections 1.6.5.3 and 1.6.5.4 call for:

> "…connectivity within and among transportation systems and modes" and

> "…a land use pattern, density and mix of uses …{that}…minimize the length and number of trips and support the development of viable choices and plans for public transit and other alternative transportation modes, including commuter rail and bus".

Policy Statement and Incompatible Land Uses

The Policy Statement also links prosperity to the separation of incompatible land uses for the protection of pubic health and safety. Section 1.7.1e) states that long-term economic prosperity should be supported by:

> "Planning so that major facilities and sensitive land uses are appropriately designed, buffered and/or separated from each other to prevent adverse effects from odour, noise and other contaminants, and minimize risk to public health and safety".

I2 Regional Official Plan

Official Plan Air Quality Objectives

The Halton Region Official Plan, updated in August 2006, clearly commits the Region to the promotion of public health and the improvement of air quality. Section 25 identifies protection of the natural environment, enhancing economic competitiveness, and fostering a healthy, equitable society as the three pillars upon which its vision of the Region is built.

Section 142 identifies a number of objectives that are directed towards the improvement of air quality. Sections 142(3), (4), (5), (6), and (7) commit the Region:

> "To reduce incrementally the overall greenhouse gas emissions and other air pollutants generated by the Region's own corporate activities and functions;"

> "To contribute to the overall improvement of air quality in Halton's airshed through facility management, land use planning, transportation management, roadway design, operation and maintenance, and other complementary programs;"

> "To support urban forms that will reduce long distance trip-making and the use of the private automobile;"
>
> "To promote trips made by walking, cycling and public transit" and
>
> "To promote tree planting in both rural and urban areas for the purposes of improving air quality and reducing energy use through shading and sheltering."

Official Plan Air Quality Policies

The Region's Official Plan also articulates a number of policies designed to move the Region towards the realization of its air quality objectives. Section 143(3) (4) (5) (6) and (7) states that the Region will:

> "Establish five-year targets for, and monitor regularly the performance of, the reduction in greenhouse gas emissions and other air pollutants generated by the Region's own corporate activities and functions;"
>
> "Promote walking, cycling and public transit over other modes of transportation;"
>
> "Require all new urban development to consider in its design the provision of pedestrian walkways, cycling paths and access to public transit services, or transit stops where they are likely to be located, within a walking distance of 400 meters;"
>
> "Require, in the re-construction or improvement of Arterial Roads, consideration be given to tree planting and landscaping initiatives to improve air quality and reduce visual impact to adjacent land uses;" and
>
> "Establish a Regional transportation management association and assist in promoting similar organizations in Halton to provide alternatives to commuting by single-occupancy vehicle".

Official Plan and Transportation Systems

Sections 171 and 172 of the Official Plan, directed towards the transportation systems within the Region, highlights the need to develop transportation systems that reduce environmental impacts and conserve energy. Section 171 indicates that the Region's goal for transportation is:

> "The provision of a safe, convenient, affordable, efficient and energy-conserving transportation system in Halton, while minimizing the impact on the environment."

These sections emphasize, among other things, the Region's commitment to:

- Develop a balanced transportation system that integrates all travel modes;
- Realize a public transit system in Halton that includes an inter-municipal rapid transit system; and
- Promote land use patterns and densities that foster strong live-work relationships that can be easily and effectively served by public transit, walking and cycling.

Official Plan and Energy Systems

Sections 174, 175 and 176 of the Official Plan, directed toward energy and utilities in the Region, highlights the need to develop energy systems that conserve energy and reduce adverse impacts. Section 174 indicates that the Region's goal for energy and utilities is to:

> "Encourage and ensure the conservation and wise economic use of energy and to minimize adverse impacts caused by its provision."

These sections emphasize, among other things, the Region's commitment to:

- Promote the use of those forms of energy that pose the least environmental risk;
- Encouraging public agencies, private industries and individuals to participate in energy conservation programs;
- Applying energy conservation techniques in Regional facilities and projects;
- Support the use of full cost accounting principles in evaluating proposals for alternative energy sources; and
- Investigate energy conservation measures and alternate generation methods that would minimize the impact to the environment.

J Assessing Air Quality and Human Health Impacts

As the air quality health impacts associated with land use planning become clearer, municipal and public health staff in various jurisdictions have been wrestling with the means to assess and evaluate the cumulative impacts of various decisions, policies and developments on air quality and human health. In the air quality field, there are a few different tools that can be used to assess air quality and inform policy development; emission inventories, air monitoring, air quality modelling, and air pollution health impact modelling.

Emissions Inventories

Emissions inventories produced by the provincial and federal governments provide estimates of the volume of air pollutants that are emitted from different sources on an annual basis. While these inventories do indicate something about the overall contribution of emission sources to regional air quality, they do not indicate how those emission sources impact on local and regional air quality because they do not indicate how air pollutants are dispersed once they are released into the air. The dispersion of air pollutants is affected by a number of factors including the location of their release, the height at which they are released, the meteorology that exists when they are released (e.g. wind direction and wind speed), and the topography of the location in which they are released (e.g. flat land or a valley).

Air Monitoring

Stationary and portable air monitoring devices measure the actual concentration of various air pollutants in the air. Stationary air monitors, such as those operated by the Ontario Ministry of the Environment, can provide continuous readings of air pollutants in a particular location. They can be used to identify peaks in air pollution and to follow trends in air quality over time. Portable air monitors can be used to measure air pollution at different points across the community. They can provide valuable information about how air quality varies from one area to another. They can also be used to monitor air quality in micro-environments such as along traffic corridors. These devices cannot however identify the sources that contribute to the concentrations measured. Nor can they predict how concentrations might be affected by new facilities, new developments, or new policies (e.g. new regulations for vehicles).

Air Quality Modelling

Air quality modelling conducted with sophisticated computer models can fill the gap left by monitoring devices and emission inventories. Using meteorological information, location, topography, and emissions data which includes the height, speed and frequency of emission releases, air quality modelling tools can estimate the concentration of different air pollutants across the community. Because these tools can examine emission sources separately, they can also assess the contribution of different emission sources to concentrations of air pollutants in different parts of the community. In addition, air quality modelling tools can be used to forecast how concentrations of air pollutants might be impacted by new emission sources or by changes in policy. In this way, they can be used to inform land use planning decisions and policy development.

Air Pollution Health Impact Modelling

Air quality experts at Health Canada and Environment Canada have developed the Air Quality Benefits Assessment Tool (AQBAT) to estimate the human health impacts associated with different concentrations of air pollutants. Using monitored or modelled concentrations of air pollutants, AQBAT can be used to estimate the health impacts associated with air quality in a community using population statistics for the community, health statistics for the community, and risk coefficients that describe the relationship between specific air pollutants and specific health outcomes. AQBAT can only be used at a community-wide basis; it has not been designed to estimate health impacts for neighbourhoods or subdivisions. It can be used to provide an estimate of the health impacts that would be associated with major changes in a fairly large community.

K Conclusion and Recommendations

K1 Conclusions

Poor outdoor air quality poses a significant risk to public health in Halton Region and in many other communities in southern Ontario. Transportation systems, fuel consumption for space and water heating and electricity generation, and industrial and open sources all represent major sources of air pollution in Ontario and Halton Region. With the growth expected in Halton Region over the next 25 years (i.e. about 375,000 residents from 2001 to about 780,000 in 2031), there will be increasing stresses on the local airshed as new vehicles, homes and workplaces are introduced to the community.

The Ontario Government's new Provincial Policy Statement and the newly revised Regional Official Plan (August 2006) clearly identify the protection of public health and the improvement of air quality as priorities to be addressed through the land use planning process. These two documents identify objectives and policies for "complete communities”, the transportation sector, energy systems, and incompatible land uses, that would, if implemented, mitigate the negative air quality and human health impacts that could be associated with growth in Halton Region. The next step is to develop the air quality assessment tools and policy instruments that support the implementation of these objectives.

The Region should develop a community-wide air quality modelling program that can be used to assess air quality and support land use planning decisions, policy development, and health promotion. It should examine the portable air monitoring equipment and/or resources that could be used to assess air quality in micro-environments and/or validate air quality modelling results.

In addition, the Region, working in collaboration with the local municipalities, should explore the policy instruments that could be used to support the development of “complete communities”, alternative modes of transportation, energy efficiency, and alternative energies in the Region. The Region should also develop a health promotion campaign to increase public awareness about the link between air quality, human health, climate change, and the built environment, and the actions needed to improve air quality and/or slow climate change.

K2 Recommendations

It is recommended:

1. THAT the 2007 Health Department Operating budget be increased by $50,000, funded by a transfer from the Tax Stabilization Reserve, to develop a community-wide air quality modelling program that can be used to assess air quality across the Region, evaluate the contribution of new emission sources on air quality, and inform land use planning decisions, policy development, and health promotion campaigns.

2. THAT the Region examine the portable air monitoring equipment and/or resources that could be used to assess air quality in micro-environments such as traffic corridors and validate air quality modelling results, to support land use planning decisions and policy development.

3. THAT the Region, in collaboration with the local municipalities, examine the policy instruments that might be used to support the development of “complete communities” that reduce reliance on automobiles in order to reduce vehicle-related emissions of air pollutants and greenhouse gases across the Region.

4. THAT the Region, in collaboration with the local municipalities, explore the policy instruments that might be used to encourage the early application of the EnerGuide 80 standard to small residential buildings, the application of LEED™ standards to large buildings, and the use of alternative or renewable energy systems in new buildings.

5. THAT the Region develop and implement a health promotion program that educates the public about the link between air quality, human health, climate change, and the built environment, and about the actions that can be taken by

individuals, organizations and governmental agencies to improve air quality and/or slow climate change.

6. THAT the Regional Chair send a copy of the staff report and this policy paper entitled, *Air Quality, Human Health and the Built Environment: Protecting Air Quality through the Land Use Planning Process,* to the Ontario Ministers of the Environment, Municipal Affairs, and Health and Long-term Care, the Chief Medical Officer of Health, all Medical Officers of Health in Ontario, the Association of Local Public Health Agencies, the Ontario Public Health Association, the Canadian Institute of Public Health Inspectors, and the Association of Supervisors for Public Health Inspectors – Ontario.

Appendix 1:

Table 1: Halton Region, All Four Communities, Emission Sources by Volume, Criteria Air Contaminants, 2004 (Metric Tonnes)(Corr, 2006)

Source Category	$PM_{2.5}$	SO_X	NO_X	VOC	CO
Industrial	759	6491	1891	5415	3923
Fuel Combustion	810	257	1052	1103	5015
Transportation	438	464	6142	3179	29291
Incineration	0	9	10	12	29
Miscellaneous	26	0	0	3644	52
Open Sources	1450	0	0	244	0
Total	3483	7221	9095	13597	38310

Table 2: Halton Region, All Four Communities, Emission Sources by Percentage, Criteria Air Contaminants, 2004 (Corr, 2006)

Source Category	$PM_{2.5}$	SO_X	NO_X	VOC	CO
Industrial	22%	89%	21%	40%	10%
Fuel Combustion	23%	3.6%	12%	8%	13%
Transportation	13%	6.5%	68%	23%	77%
Incineration	0	0.1%	0.1%	0.1%	0.1%
Miscellaneous	0.1%	0	0	27%	0.1%
Open Sources	42%	0	0	1.8%	0
Total	100	100	100	100	100

Appendix 2:

Estimating Emissions Associated with Vehicles, 400,000 Additional People, Two Scenarios, Current Day Emission Rates

Two- Vehicle Households Scenario:

400,000/3 x 2 cars x 50 km/day x 1.3 g/VKT =17,333,333 g/day or 17.333 tonnes/day
17.333 x 5 days/wk x 52 weeks = 4,507 tonnes/year plus
400,000/3 x 2 cars x 5 km/day x 1.6 g/VKT = 2,133,333 g/day or 2.133 tonnes/day
2.133 x 2 days/wk x 52 weeks = 222 tonnes/year
Total = 4,729 tonnes of NO_x/year
(Emission rates from Air Quality Management Strategy, Halton, 2004a)

400,000/3 x 2 cars x 50 km/day x 100 to 300 g/VKT =1,333 to 4,000 tonnes of CO_2/day
1,333 to 4,000 x 5 days/wk x 52 weeks = 347,000 to 1,040,000 tonnes of CO_2/year
400,000/3 x 2 cars x 5 km/day x 100 to 300 g/VKT = 133 to 400 tonnes of CO_2/day
133 to 400 tonnes/day x 2 days/wk x 52 weeks = 13,832 to 41,600 tonnes of CO_2/year
Total = 360,800 to 1,082,000 tonnes of CO_2/year (for all hybrids to all SUVs)
(Emission rates from Climate Change Action Plant, Canada, 2002).

One-Vehicle Households Scenario:

400,000/3 x 1 cars x 50 km/day x 1.3 g/VKT = 8,667,000 g/day or 8.67 tonnes/day
8.67 x 5 days/wk x 52 weeks = 2,254 tonnes/year plus
400,000/3 x 1 cars x 2.5 km/day x 1.6 g/VKT = 533,000 kg/day or 0.53 tonnes/day
0.53 x 2 days/wk x 52 weeks = 55.5 tonnes/year
Total = 2,309.5 tonnes of NO_x/year
(Emission rates from Air Quality Management Strategy, Halton, 2004a).

400,000/3 x 1 car x 50 km/day x 100 to 300 g/VKT = 667 to 2,000 tonnes CO_2/day
667 to 2,000 tonnes/day x 5 days/wk x 52 weeks = 173,000 to 520,000 tonnes CO_2/year
400,000/3 x 1 car x 2.5 km/day x 100 to 300 g/VKT = 33 to 100 tonnes of CO_2/day
33 to 100 tonnes/day x 2 days/wk x 52 weeks = 3,400 to 10,400 tonnes of CO_2/year
Total = 176,400 to 520,400 tonnes of CO_2 /year (for all hybrids to all SUVs)
(Emission rates from Climate Change Action Plant, Canada, 2002).

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