Sustainable Halton

Climate Change

May 2007

Sustainable Halton

This is a draft final background report for the Sustainable Halton planning process. As the project continues and as we receive public feedback, there may be slight adjustments made to the content of this report.

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Acronyms

CC	Climate Change
CFC	Halocarbons (see Appendix 2)
CH4	Methane
CO2	Carbon Dioxide
CO2	Carbon Dioxide
CO2e	A term used to convert different GHG's to a common measure -the amount of CO2 that would have the equivalent global warming potential.
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GTA	Greater Toronto Area
GWP	Global Warming Potential
HCFC	Halocarbons (see Appendix 2)
HFC	Halocarbons (see Appendix 2)
IPCC	International Panel on Climate Change
N2O	Nitrous Oxides
NRTEE	National Round Table on the Environment and the Economy
PFC	Halocarbons (see Appendix 2)
ppm	parts per million
SF6	Halocarbons (see Appendix 2)
SHP	Sustainable Halton Plan

Acknowledgments

In preparing this review, we reviewed a number of background reports prepared by various consultants as part of the Sustainable Halton Plan process. We would like to acknowledge the authors of these reports.

Executive Summary

Context

Ontario's population continues to grow and municipalities are considering how best to prepare for, and respond to, growth in their communities. Under the provincial *Places to Grow* framework, Halton could be home to 780,000 Ontarians by 2031. The Ministry of Public Infrastructure and Renewal has instructed the Region of Halton to consider the potential planning issues and impacts associated with this population growth.

This paper is one in a series of background papers intended to help planners anticipate issues when designing planning processes to accommodate growth of this scale. In particular, this paper has been commissioned by the Region of Halton to provide a discussion of Climate Change and how it may impact Halton.

Objective

The purpose of this study is to provide an overview of current information on Climate Change, how elements of the Sustainable Halton Plan might contribute to reducing the Region's future greenhouse gas emissions and how the Plan might anticipate and adapt to changes that may result from Climate Change.

Climate change Impacts

The Intergovernmental Panel on Climate Change (IPCC) recently issued a report which confirms, with over 90% certainty, that our climate is warming and that warming is being caused by human activity. Globally we are emitting approximately 3.5 billion tonnes of carbon into the atmosphere annually *in excess* of the atmosphere's ability to absorb it[1]. Over the past 650,000 years, atmospheric CO2 levels have ranged between 180-300ppm[2]. Since the start of the industrial revolution CO2 levels have increased from 280ppm in 1750 to 379ppm in 2005; well above historic ranges.

Greenhouse Gases (GHG's) have a very long life in the atmosphere. Emissions already released into the atmosphere mean that warming of the globe will continue at an average rate of 0.1 degree Celsius per year for the next two decades; even if GHG levels had been frozen at year 2000 concentrations[3]. Therefore, a two degree Celsius temperature rise is effectively "locked in". Climate models predict that if CO2 concentrations reach 550ppm, temperatures are expected to increase 3-5 degrees with serious global implications. In order to limit global temperatures increase to 2 degrees, we need to stabilize atmospheric CO2 concentrations at around 450ppm[4].

To stabilize GHG concentrations in the atmosphere[5] below 550ppm (the level required to limit global temperature increases to between 2-3 degrees) would require an investment of about 1% of annual global GDP. The costs associated with climate change impacts if this investment is not made amount to a 5-20% loss of global GDP.

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[1] 2006, Stern.
[2] 2007, IPCC.
[3] This is a result of the slow response of oceans and their role in regulating temperature. (2007, IPCC)
[4] 2006, Stern.
[5] Cost to stabilize GHG emissions at 500-550ppm by 2050.

Immediate investment in mitigation should be seen as a least cost solution to ensure that the future costs of adaptation are manageable.

Approximately 74%[6] of Canadian GHG emissions are related to energy use. Another 13%[7] arise from non-energy agricultural and industrial processes, 3%[8] from waste and wastewater and 10%[9] to land use.

Between 1995 and 2005, the world's climate experienced the largest change in the last 200 years. Warming is accelerating faster in higher latitudes than at the equator, meaning that Canada will continue to see more significant warming than other nations. The general impacts of climate change include melting polar ice, rising sea levels, more frequent extreme weather events and changing precipitation patterns. While Halton Region may not be directly impacted by some of these changes, the indirect impacts from international climate related disruptions may be significant.
Some specific projections for the areas including Halton Region are outlined in the report.

Policy Implications:

Climate change may have significant consequences and impact costs on several areas of municipal responsibility. On the other hand, municipal decisions can significantly influence Canada's future GHG emissions.

Planning issues addressed in the background reports for the Sustainable Halton Plan have implications both for future levels of GHG emissions and for the Region's ability to adapt to future changes resulting from climate change. Some key mitigation and adaptation strategies for Halton region include the following planning categories:

- Transportation will continue to represent a key target for GHG emission reduction strategies. Municipal decisions on land use and transportation planning can have long lasting influence over transportation options. Conversely the Region will need to anticipate climate change impacts on transportation infrastructure.
- Agricultural, natural heritage systems, and aggregate: preserving natural and agricultural land areas can help maintain the ability of these areas to respond to stresses caused by climate change.
- Housing and economic growth: The Region's planning and economic policies can play a significant role in reducing future energy use (ie. intensification, support for sustainable development options) as well as in incorporating adaptation considerations.
- Infrastructure services: The Region's role in planning, developing, operating and maintaining key infrastructure the Region provides an opportunity to implement both policies to reduce GHG emissions and to anticipate and adapt to Climate Change. Road systems, waste, water and wastewater, and energy supply will all be impacted by future climate change.

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[6] Calculated based on NRCan's National GHG Inventory - 2004 data.
[7] Calculated based on NRCan's National GHG Inventory - 2004 data.
[8] Calculated based on NRCan's National GHG Inventory - 2004 data.
[9] Calculated based on NRCan's National GHG Inventory - 2004 data.

- Public services: Community agencies and services can and will play a central role in mitigating, educating and providing support for CC impacts. Expanding these service areas as integrated hubs within the region will support efforts to maintain access to health care, community/social services, education, policy, housing etcetera, while also creating environments to support and implement community-wide climate mitigation and adaptation responses.

1 CONTEXT

As Ontario's population continues to grow municipalities are considering how best to prepare for, and respond to, growth in their communities. As a result, planners and municipal leaders have begun a dialog and a process to design appropriate planning strategies and frameworks in order to accommodate potential growth. Halton region, given its many favourable characteristics such as its proximity to GTA and greenbelt is preparing for a significant portion of Ontario's population growth.

Under the provincial *Places to Grow* framework, Halton could be home to 780,000 Ontarians by 2031. This means that Halton will have to plan for an additional 151,000 people beyond the beyond the 2021 planning horizon identified in the Region's 2006 Best Planning Estimates. As a result, the Ministry of Public Infrastructure and Renewal has instructed the Region of Halton to consider the potential planning issues and impacts associated with population growth to 2031. This task will require planners to reflect on a comprehensive set of local issues including energy, health, services, land use, and infrastructure for example.

This paper is one in a series of background papers intended to inform this emerging dialog and help planners anticipate issues when designing planning processes to accommodate growth of this scale. In particular, this paper has been commissioned by the Region of Halton to provide a discussion of climate change and how it may impact Halton. The paper is primarily focussed on how opportunities to reduce future greenhouse gas emissions and prepare the Region to adapt to future climate change in the context of the Sustainable Halton process, however, we have also included some discussion of issues and policy options which extend beyond this process.

2 OBJECTIVE

The purpose of this study is to provide an overview of current information on Climate Change, how elements of the Sustainable Halton Plan might contribute to reducing the Region's future greenhouse gas emissions and how the Plan might anticipate and adapt to changes that may result from Climate Change.

The specific objectives of the report are to:

- Provide an overview of the latest information available regarding the processes of Climate Change and its implications for southern Ontario and the Region of Halton.
- Discuss potential policy responses at the National and Provincial level which may impact the policy environment in which the Sustainable Halton Plan will be implemented.
- Review the background papers prepared to-date as part of the Sustainable Halton Plan and comment on 1) How the issues addressed might contribute to emission reduction targets, and 2) How Climate Change might impact on the area (i.e. potential implications of more frequent severe weather events to emergency response plans and infrastructure, possible changes to precipitation and degree days to local agriculture and natural heritage system, etc.).

- Summarize the implications of Climate Change both in terms of emission reduction strategies and adaptation to the Sustainable Halton process.

3 FINDINGS OF STUDY

3.1 OVERVIEW

In the last few years climate change (CC) has emerged as a significant public concern, at both the global and national level. The scale and magnitude of the risks associated with CC have elevated it to the front-page of both newspapers and policy briefings. The climate effects of steadily increasing levels of greenhouse gases (GHGs) in the atmosphere will have consequences for economies, societies, and ecosystems around the world, it has become a common thread in policy agendas.

Global climate change is generally described as an overall warming effect. Global average temperatures have increased significantly on every continent[10], with temperatures in the artic increasing at a pace that is twice the global average[11]. Oceans absorb a large share of this atmospheric temperature increase, warming ocean temperatures (up to depths of 3000m[12]). This in turn fuels more intense tropical storms and contributes to a rise in sea level as the water warms and expands. Melting arctic ice, particularly land based ice, is also a serious concern as a rise in sea levels would threaten coastal settlements and reduce access to fresh water in low laying regions. Changed precipitation patterns and increased risk of extreme weather events are also a core impact of global climate change, affecting all continents to some degree and impacting agriculture, services, economies and ecosystems. Lastly, as regional climates change around the world, the risk of species extinction will be considerably elevated as basic ecosystem relationships are altered. Many species will be unable to migrate at the required pace, availability of food sources and access to breeding areas will be reduced, predator/competition relationships will change, and isolated or non-migratory populations will struggle to adapt to their new environments in time. These are only a few of the high profile global impacts, however climate change will have unique and complex impacts regionally.

> "…the last time the Arctic and Antarctic were three degrees Celsius (5.4 degrees Fahrenheit) warmer—roughly 125,000 years ago—sea levels rose by as much as six meters (20 feet) thanks to the melting of the Greenland ice sheet."
>
> (2007(a), Scientific American.)

> "Studies have already estimated that species such as butterflies are creeping toward the poles at a rate of six kilometers per decade as temperatures rise."
>
> (2007(b), Scientific American.)

Disagreement over the cause of climate change has fueled the international debate and created uncertainty about how best to respond to the risks of climate change. One camp argues that the accumulation of GHGs in the atmosphere due to human activities such as the combustion of fossil fuels and land use change (deforestation)

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[10] See Appendix A: Global and Continental Temperature Change.
[11] 2007, IPCC.
[12] 2007(a), Scientific American.

are changing the earth's climate. The other camp argues that the current observed changes in climate are due to natural variations and are not human induced. Skeptics of climate change also argue that modeling climate trends and predicting future impacts of different degrees of warming is problematic and inaccurate. While the skeptics are correct in pointing to the difficulty of modeling a system as complex as the earth's climate, the growing accuracy and detail of these models continues to strengthen the case that humans are responsible for changes to our climate.

Based on historical data, climate models are now able to accurately project climate changes which accurately match with observed patterns. This has validated the models and provided confidence in the models' abilities to predict future changes. Some of the projected changes due to CC beyond changes in average global temperatures include greater warming in high latitude regions such as the arctic, greater warming at night than in the day and greater warming in the winter than in the summer[13]. These projections all match with observed real-world changes and would not be explained by natural variations caused by fluctuations in solar radiation or other causes proposed by CC skeptics.

With increased certainty and consensus that observed climate changes are the result of human activities, the debate has increasingly shifted from the science of climate change to a discussion of policies and actions aimed at first stabilizing and then reducing GHG levels in the atmosphere.

When discussing climate change it is important to understand that these gases have a very long life in the atmosphere and that emissions already released into the atmosphere will continue to affect our climate for decades to come. For example, the quantity of GHGs emitted into the atmosphere to date have already committed us to a certain level of climate change and the associated impacts over the next 50-100 years. This has two critical implications. The first is that we need to act before we see the "worst" of the projected impacts of climate change. The second is that we must begin now to develop climate change policies which respond to these unavoidable impacts while at the same time reducing future emissions to avoid further changes in the longer term.

In order to achieve a marked improvement in GHG emissions, societies and communities will need to significantly adjust current practices. While this transition will undoubtedly encounter challenges, there will also be substantial opportunity. Some sectors will be required to take a greater role than others, but proficient planning and targeted policies can manage this transition. Over time societies have become adept at responding to changing circumstances. What makes climate change unique is that it will require a coordinated international effort over a relatively short timeframe. Delayed action will intensify the level of response required in future.

An effective climate change response suggests that municipalities engage directly in emissions reductions strategies and policy. Given their jurisdictional responsibilities, municipalities will play a role in our ability to meet national targets. This is because a significant amount of our emissions in Canada can be directly influenced by municipal planning, policy and legislation. At the same time, the impacts of climate change will directly impact areas of municipal jurisdiction and local councils will need to develop

[13] 2007, Bulletin of the Atomic Scientists, pp 41.

mitigation and adaptation strategies in response. Developing planning strategies early that are flexible and able to adjust to changing environments and economies will be important.

The following report will highlight factors to be considered in long-range planning activities for Halton Region. The first section will provide an overview of the latest information available regarding the processes of Climate Change and its implications for southern Ontario and the Region of Halton. The second section will discuss potential policy responses at the National and Provincial level which may impact the policy environment in which the Sustainable Halton Plan will be implemented. Lastly, the third section will review the background papers prepared to-date as part of the Sustainable Halton Plan and comment on how these planning areas can affect, or will be affected by, climate change.

3.2 REVIEW OF CLIMATE CHANGE INFORMATION

3.2.1 What is Climate change

Like our weather, the earth's climate goes through a number of natural variations. Over time the earth has experienced periods of warming and cooling; including repeated ice ages. Our weather also goes through seasonal cycles and minor variations from year to year. While these variations are normal and expected, Climate Change refers to the impacts of a gradual increase in global temperatures resulting from human induced increases in greenhouse gases (GHG's) in the atmosphere.

> "The term 'weather' describes the day-to-day and hour-by-hour changes in atmospheric conditions at a given location. 'Climate' describes the synthesis of these day-to-day variations into a set of average or expected conditions."
>
> (2006(a), NRCan.)

The term GHG refers to a group of gases that share the common characteristic of acting to "trap" heat in the atmosphere like glass in a greenhouse. These gases, include carbon dioxide (CO2), methane (CH4), nitrous oxide (N20), and halocarbons (CFC, HCFC, HFC, PFC, SF6)[14]. These GHGs play a key role in the stability of the earth's surface climate by trapping a percentage of the sun's energy in the lower atmosphere. A layer of GHGs act as a filter bouncing part of the sun's energy back into space but trapping a percentage of the sun's energy as light and heat in the atmosphere. The energy that remains in the atmosphere warms the planet to create a habitable surface climate. Some climate change skeptics have argued that GHG's are actually beneficial, since without them our planet would be largely uninhabitable. While it is true that some "greenhouse effect" is beneficial, anyone who has spent time in an enclosed car in the summer knows that too much of that effect is not.

> "Without this insulation, Earth would be about 33°C colder than it is now, making it inhospitable to life."
>
> (2006(a), NRCan.)

The concentration and composition of GHGs in the atmosphere determine the amount of heat that is trapped. This balance is key to maintaining a stable climate. As the quantity of GHGs increase they absorb and trap more of the sun's energy. This upsets

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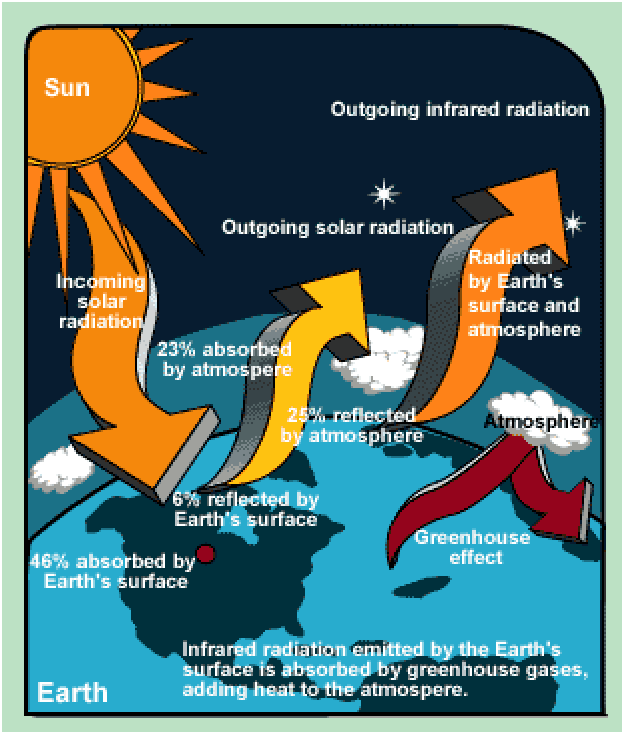
[14] See Appendix B for additional information on specific greenhouse gases.

the balance of solar energy stored and reflected, in turn warming the earth's atmosphere (see figure below).

Figure 1: Greenhouse Gas Effect



Source: (2006(a), NRCan.)

Each of the GHGs mentioned above have a different impact or contribution to climate change. Each persists in the atmosphere for different lengths of time and each GHG has a different capacity to absorb heat, referred to as its *Global Warming Potential* (GWP)[15]. The three most important GHGs influencing the stability of climate are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). This is due to the sheer abundance of CO2 in the atmosphere and the high GWP of CH4 and N2O. For example if not removed by some natural process, CO2 persists in the atmosphere for up to 200 years[16], meaning that a CO2 molecule emitted today could still be contributing to global warming through the lives of our great grandchildren. On the other hand, N2O persists for approximately 120 years[17] and CH4 persist between 10-15 years[18] but their GWP are 310 and 21 times[19] higher then CO2 respectively. This means

[15] See Appendix B: GWP and Atmospheric Lifetimes for details.
[16] 2001, IPCC.
[17] 2006(b), NRCan.
[18] 2006(b), NRCan.
[19] 2006(b), NRCan.

saving one molecule of CH4 from being emitted is like saving 21 molecules of carbon dioxide.

This ability of GHGs to persist for long periods of time in the atmosphere is a central issue for designing a climate change response strategy. As mentioned above, even if we halted emissions of GHGs today, we will continue to experience impacts of climate change for the next 50-100 years due to the amount of GHGs that have already been emitted into the atmosphere.

It is also important to note that while climate change is often referred to as global warming, its implications are more far-reaching than a general and steady temperature increase or changing weather. "Warming" the climate will disrupt natural climate cycles and weather systems, and upset complex ecosystems. Some of the general changes driven by this "warming" are projected to include:

- altering precipitation patterns and increasing both floods and droughts;
- contributing to sea level rise in part due to melting polar ice and glaciers;
- increasing extreme weather events, with resulting increases in damage to infrastructure, access to fresh water and agricultural yields;
- shift natural habitats with resulting impacts on species extinction, health impacts and the occurrences of invasive species.

3.2.2 What causes climate change

A combination of factors and variables influence climate systems and trends. However, the most prevalent factor contributing to the rapid and unprecedented changes in climate since the industrial revolution, are increased levels of GHG gases in the atmosphere. These changes are intensifying as a result of increased levels of GHG emissions from human activities – primarily the combustion of fossil fuels. The human activities that are responsible for the increasing levels of emissions can be grouped into four main areas.

1. **Energy Use**

Whenever we use fossil fuels as a source of energy to drive our cars, power our equipment/electronics and heat our buildings, it results in emissions into the atmosphere - including a mix of smog pollutants, heavy metals, particulate matter, and GHGs. The emissions associated with generating heat, electricity and transportation services are a significant contributor to climate change as they account for approximately 74%[20] of Canada's overall GHG emissions.

In order to reduce these emissions, we must reduce overall demand for fossil fuels. Better design, planning, technology efficiency gains, and switching to less carbon intensive fuels can all contribute to lower carbon emissions. There are also opportunities to capture and store CO2 emissions, either through technology applied in the oil and gas sector and fossil fuel power plants, or in natural systems such as forests.

[20] Calculated based on NRCan's National GHG Inventory - 2004 data.

2. Non-Energy Agricultural and Industrial Processes

The agricultural and industrial sectors also generate emissions that are not related to their energy use. These non-energy activities represent approximately 13%[21] of Canada's overall GHG emissions.

In the agricultural sector, extensive fertilizer application and tillage practices release nitrous oxides into the atmosphere. Methane emissions from livestock are also a significant source of emissions.

In the industrial sector, non-energy emissions are released during industrial processes such chemical production, petroleum refining, cement production, and steel smelting.

To reduce emissions from these non-energy activities we must reduce the use of synthetic fertilizers, implement low or no till agricultural practices, substitute inputs in industrial processes that react to form emissions and apply new technologies that can capture and store emissions or result in process changes.

3. Waste and Wastewater

Waste and wastewater sources generated by all sectors of society also emit GHGs into the atmosphere. The decomposition of organic materials in waste and wastewater releases methane into the atmosphere which contributes to global warming. Current landfill practices and wastewater management are therefore the primary sites of emissions in this activity area which accounts for a modest 3%[22] of Canada's total GHG emissions.

In addition to reducing the overall quantity of waste we produce, applying technologies such as landfill gas capture equipment can reduce the quantity of emissions from this sector. Since these gas capture technologies also generate electricity and/or heat, they can contribute a secondary GHG reduction benefit by displacing a portion of fossil fuel generated supply.

4. Land Use

Land uses, such as forests, wetlands[23], croplands, and grasslands can act to either capture or release GHG emissions (referred to as sources and sinks). Forests and other vegetation absorb carbon dioxide particles from the air and store it in plant tissue as part of photosynthesis. Therefore, as the quantity of forest and vegetation cover is reduced (through deforestation, fires, and natural events), one of the earth's natural carbon balancing systems is reduced and more GHGs persist in the atmosphere to accelerate warming. The net contribution of GHGs from this area represent approximately 10%[24] of Canada's GHGs.

Forest fires or natural events not only reduce the overall land use area available to act as a sink for carbon emissions but, the combustion of biomass in fires or the decomposition of biomass after a natural event are also sources of GHG emissions (primarily methane and/or CO2). This can result in a positive feedback as extreme

[21] Calculated based on NRCan's National GHG Inventory - 2004 data.
[22] Calculated based on NRCan's National GHG Inventory - 2004 data.
[23] Note: counter to the other land uses listed in this activity area, wetlands are a source of methane emissions.
[24] Calculated based on NRCan's National GHG Inventory - 2004 data.

weather events or increasing temperatures resulting from climate change can increase the risk of forest fires – leading to greater releases of carbon into the atmosphere.

Protecting these land uses, preserving more natural areas, and diligently managing existing resources will help reduce emissions and increase the potential for these areas to act as a robust carbon sink.

3.2.3 State of the Science

There is no longer question in the scientific community that climates are changing and that human actions are the leading contributor. Research efforts have moved away from studies assessing the role of human versus natural drivers of climate change towards studies aimed at identifying the range of impacts that could be experienced in different regions as a result of different warming scenarios.

Recent publications by leading policy, research and academic organizations are clarifying the complex relationship between atmospheric GHG levels, ecosystem changes and the social and economic costs of mitigation versus adaptation. The common message emerging from these studies is that that CC is happening and that how we respond now will determine not only the severity of impacts and costs in the future but also our ability to adapt.

The Science: The Intergovernmental Panel on Climate Change Fourth Assessment Report

Building on almost 20 years of international collaboration, the Intergovernmental Panel on Climate Change (IPCC) recently released a summary of their latest assessment of climate change. The latest findings, based on peer-reviewed scientific research, verify and strengthen the IPCC's position that the earth is warming driven by GHG levels which have increased markedly from pre-industrial levels due to human activities. Increased atmospheric concentrations of carbon dioxide levels are attributed to fossil fuel combustion and land use change while nitrous oxide and methane increases are primarily attributed to agriculture. Current studies suggest that we are emitting approximately 3.5 billion tonnes of carbon into the atmosphere annually _in excess_ of the atmosphere's ability to absorb it[25].

> The IPCC was established in 1988 and is open to participation from all members of the United Nations and the World Meteorological Organization.
>
> The IPCC undertakes objective and transparent reviews of international scientific research and data and reports on the impacts of climate change. Their first IPCC Assessment Report was completed in 1990.

The IPCC report confirms, with over 90% certainty, that the net impact of increased concentrations of GHGs in the atmosphere, since 1750, has been one of a global warming[26]. Eleven of the past twelve years

> New data shows that losses from ice sheets in Greenland and Antarctica very likely contributed to global sea level rise between 1993 and 2003.
>
> (2007, IPPC, pp 7.)

[25] 2006, Stern.
[26] 2007, IPCC.

have ranked as the warmest years since accurate global surface temperature records began in 1850[27]. The observed increases in ocean and air temperatures coupled with widespread melting of snow and icecaps and rising sea levels illustrate this "unequivocal change"[28].

Given its abundance, the IPCC's *4th Assessment Report Summary* has identified CO2 as the most important anthropogenic GHG contributing to climate change. CO2 has increased from 280ppm in 1750 to 379ppm in 2005, which falls well above historic CO2 ranges. To put this in context, over the past 650,000 years, CO2 levels have ranged between 180-300ppm[29]. We are now already well above the upper end of that historic range.

In order to limit the increase in global temperatures to 2 degrees, climate models show that atmospheric carbon concentration will need to be stabilized at 450ppm[30]. However the Stern Review indicates that we are on target to reach this concentration within a decade and it will be very difficult to stabilize to that level even with immediate and aggressive reduction strategies. If CO2 concentrations double pre-industrial levels and exceed 550ppm, temperatures are expected to increase 3-5 degrees with serious global implications.

The IPCC study confirms that warming of the globe will continue at an average rate of 0.1 degree Celsius per year for the next two decades; even if GHG levels had been frozen at year 2000 concentrations[31]. Therefore, a two degree Celsius temperature rise is effectively "locked in," regardless of our policy response. This is due to timelines of climate processes and feedback cycles. Considering the time required for CO2 and other GHGs persist in the atmosphere and the role of carbon feedback cycles, it is estimated that past and future CO2 emissions "will continue to contribute to warming and sea level rise for more than a millennium"[32].

Stabilizing atmospheric CO2 levels at 450-550ppm will require global emission reductions of approximately 60% from current emission rates by 2050, which – given the projected growth in the global economy – would mean about an 80% reduction from business as usual. If that target is achieved, there is a 50/50 chance that the increase in global mean temperature can be held close to two degrees Celsius[33] which increases our chances to mitigate and adapt to the impacts of climate change.

3.2.4 The Economics of Climate Change

With scientific evidence now indicating that human activities are the primary driver of past and future climate change, the debate has largely shifted focus to 1) how society can achieve the kind of dramatic reductions in GHG emissions required to stabilize atmospheric concentrations of GHGs and curb climate change and 2) what investments will be required to achieve those kinds of reductions?

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[27] 2007, IPCC.
[28] 2007, IPCC.
[29] 2007, IPCC.
[30] 2006, Stern.
[31] This is a result of the slow response of oceans and their role in regulating temperature. (2007, IPCC)
[32] 2007, IPCC, pp17.
[33] 2006, Stern.

In 2006, a study analyzing the potential costs, risks and trade offs associated with different warming scenarios concluded that the economics of early mitigation strategies (defined as measures implemented early to prevent the impacts of CC) are preferred over future adaptation strategies (defined as actions taken in response to impacts of climate change). The study found that if GHG emissions are left unchecked over the next 10-20 years, the impacts of climate change could significantly disrupt economic systems[34]. Therefore, investments in mitigation activities are necessary in the immediate and short term to reduce the risk of climate impacts on economies in the long term. These immediate mitigation costs should be seen as investments that are necessary to ensure the costs of adaptation in the future are manageable.

> "The scientific evidence points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual paths for emissions…[and therefore]…the benefits of strong, early action on climate change outweigh the costs."
>
> (Stern, 2006, pp i - iii.)

The Stern Review was commissioned by the British government to assess the economics of climate change and their potential impact on the UK. The study was led by economist Sir Nicholas Stern, former economist to the World Bank. The report estimated the cost of programs needed to stabilize GHG concentrations in the atmosphere[35] below 550ppm – the level required to limit global temperature increases to between 2-3 degrees. It found the investment required would equal approximately 1% of annual global GDP. While this represents a substantial investment from the world's economy, the review also estimated the cost of the alternative. Failure to make this investment, it found, could result in climate change impacts that would result in 5-20% loss of global GDP.

> "At higher temperatures, developed economies face a growing risk of large-scale shocks-for example, the rising cost of extreme weather events could affect global financial markets through higher and more volatile costs of insurance"
>
> (2006, Stern.)

Stern's message is that the world will face costs associated with climate change regardless of the path chosen. These costs will not be borne equally across regions or economic sectors. However, pursuing mitigation strategies will simultaneously create new business opportunities; as markets for low-carbon, high-efficiency goods and services expand[36] and avoid greater costs in the long run. There is an enormous technical potential for energy efficiency improvements, which has been identified as the largest single source of emissions reduction potential in the energy sector[37]. Clean power, heat and transportation technologies are also identified as key mitigation investments. The Stern report estimates that the global power sector will need to be up to 70% de-carbonized by 2050 in order to reach targeted levels of global emission reductions. Actions to reduce deforestation are also identified in the review as among the lowest-cost mitigation options, and non-energy emissions are highlighted as an important area that could contribute reductions.

[34] Stern argues that these impacts can create economic and social disruptions on a similar scale to those experienced during the great wars or the depression.
[35] Cost to stabilize GHG emissions at 500-550ppm by 2050.
[36] 2006, Stern.
[37] International Energy Agency study quoted in 2006, Stern.

In sum, the review concludes that, “the earlier effective action is taken, the less costly it will be”[38].

3.2.5 Impacts of Climate Change

Between 1995 and 2005, the world’s climate experienced the largest change in the last 200 years. While in the short-term regions might enjoy on average milder winters, warmer summers and increased growing degree days, the impacts of climate change are estimated to outweigh these initial effects. We do not yet know what all of the impacts of continued warming will be, however some predicted impacts include:

- continued reduction of snow cover and sea ice;
- continued increase in the number of extreme heat days,
- extreme storm and heavy precipitation events leading to flooding, damaging crops, infrastructure and fragile ecosystems;
- continued sea level rise threatening coastal settlements and access to fresh water;
- increased drought in subtropical regions;
- changing wind patterns influencing storm patterns.

Furthermore, warming tends to reduce the ability of soils, vegetation and oceans to absorb CO2 in turn increasing the concentration of CO2 in the atmosphere.

Given that warming is accelerating faster in higher latitudes than at the equator, Canada will continue to see more significant warming than other jurisdictions. Our artic region, for example, is undergoing significant and rapid change that will impact not only ecosystems in the area but resource extraction, pipelines and shipping. Due to the diversity of bioregions and ecosystems across Canada the scope of impacts in Canada will vary widely. The implications of climate change will differ for our artic ecosystems, our prairie regions, the boreal forests, the rocky mountains, coastal marine habitats and great lakes region. Therefore, it is important that each region assess potential climate change impacts for their specific bioregion and location.

As part of Southwestern Ontario, Halton Region lies in a temperate zone that experiences four full seasons. Its local climate is affected by its proximity to the Great Lakes and to a lesser extent by the Niagara Escarpment, Greenbelt and the heat island effect of the GTA. The major land uses within the region are urban and rural settlements (including residential, commercial and manufacturing), farmlands (including managed and intensive agriculture: livestock, cash crops, nurseries, horse farms, fruit and vegetable producers); aggregates; natural heritage assets (forests and protected countryside) and recreational areas (lakefronts, parks).

Given the economic base and environmental characteristics of the region, some of the potential impacts of climate change for Halton include:

Warming in the region to date has already resulted in noticeable shifts in the timing and duration of seasons and this **seasonal shift** is expected to continue.

- Warmer temperatures may create more favorable climates for many invasive plant species threatening various local ecosystem balances, as well as invasive

[38] 2006, Stern, pp ii.

species increasing the risk of insect and rodent borne diseases such as mosquito-borne West Nile virus or Lyme disease carried by ticks.

- Decreasing snow pack can affect ground water systems and local hydrological cycles.
- Increased precipitation patterns combined with earlier springs can intensify the spring thaw increasing river flows, erosion around rivers, and erosion of farmlands. Shorter winters and earlier spring thaws may also impact fresh water systems and marine life. Over the last 100-150 years the duration of ice cover on the Great Lakes has been reduced by 1-2 months (about 3.5 days per decade)[39]. Less ice cover on the Great lakes could boost water loss from evaporation and shoreline erosion in winter storms, as well as impact lake-effect snowfall[40].
- Increasing water temperatures in the Great Lakes can impact spawning cycles, increase invasive species and occurrences of algae blooms, and negatively impact cold water fish stocks[41].
- Occurrences of flooding will become more frequent in the winter months with warmer temperatures, shifting slightly away form spring flooding. This creates pressure on storm water infrastructure and management plans (especially in built urban environments) responding to higher requirements for local water diversion, drainage and treatment during flooding.
- Intensified spring flows and heavy precipitation events in winter/spring can increase the risk of spreading waterborne diseases. For example, contamination of the municipal water system in the town Walkerton (located northwest of Halton in Bruce County). And this also impacts on waste water colletion and treatment due to infiltration and inflow
- Costs associated with water supply, treatment and diversion as well as lost agricultural revenue could increase (drier.summer months and drought periods may result in higher peak flows required for water supply as well as impact of lower lake levels and groundwater aquifer levels)
- Earlier springs have impacted the timing of a number of natural processes, from germination of plants to the migration of species such as birds. In general, shifting seasons and the associated changes in the natural environment may stress or fracture ecological relationships. These relationships, which have developed over long periods of time, may not be able to adjust to rapid changes in climate. While these impacts are important to the species involved, they may also disrupt many of the natural "services" we rely on, such as birds that maintain checks on insect populations, the pollination of plants and crops or water filtration services provided by marshlands and ground water systems. These disruptions can have significant economic consequences.

Water levels in the Great lakes are showing a receding trend which will threaten coastal wetland habitats. These habitats are important breeding and wintering grounds for many water fowl and fish species.

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[39] 2003, Kling et al.
[40] 2006, Mortsch et al.
[41] 2003, Kling et.al.

Despite the abundance of fresh water in the region, seasonal shortages will increase during the drier summer months. These shortages have already been documented in the region of Waterloo, just west of Halton Region[42]. Shallow wells and smaller ground water sources will be particularly vulnerable. Some hydro generation will also be vulnerable to seasonal hydrological cycle shifts although this is not a significant factor in Halton.

Regions like Canada located in higher latitudes are predicted to experience some net benefits if average **temperatures** increase between 2-3 degrees Celsius.

- higher agricultural yields (especially crops including soybeans, corn[43], sorghum, maize as well as some fruits)
- lower winter mortality
- lower heating requirements
- increased tourism and recreational revenues for warm weather activities (golf, fishing, water sports et cetera)

The impacts of **extreme weather** events associated with a 2-3 degree warming are expected to counteract some of the earlier benefits and will increase in intensity at higher temperatures.

- Seasonal weather events will intensify (mid-end of summer droughts and increased frequency of heavy precipitation in winter-spring).
- Summers in the region will experience increased and prolonged heat waves, as well as more smog and poor air quality days. Local quality of health will be impacted significantly (especially elderly and youth) and health care costs will increase due to the increase of demand for hospital visits, treatments and stays.
- Extreme weather can have damaging impacts on infrastructure causing disruptions in services, lost revenue, health impacts and costs to repair. Ontario's transmission and distribution are vulnerable to such storm impacts as shown by the ice storm in eastern Ontario and numerous outages caused by severe storms in northern Ontario in 2006.
- Transportation and shipping systems and infrastructure are also vulnerable to climate warming and weather events (such as road and railway heaving/buckling and snow and ice control) which could have significant impacts on local economic activities, increase the cost of goods and services being provided from outside the region and require investments in repair. To the extend that the frequency of winter snow is reduced there may be some offsetting savings to municipal budgets.

Extreme weather events to date in Canada include:

- 1985 Barrie tornado,
- 1998 Ottawa ice storm,
- 1999 Toronto snow storm,
- 2006 Prairie floods,
- 2006 Vancouver winter/wind storms
- Annual mudslides and forest fires

[42] 2001, De Loe et al.

[43] *Climate Change Impacts and Adaptation Research Network, (Ellen Wall, Barry Smit and Johanna Wandel), Canadian Agri-food Sector Adaptation to Risks and Opportunities from Climate Change*

- The winter activity and downhill skiing share of the recreation and tourism industry will be expected to experience lower revenues as the winter season shortens.
- Insurance costs will increase in response to property damage from climate related weather events.

In addition to extreme weather, factors such as pest and disease **infestations**, or air pollution and acid deposition may negate the benefits of warming for agricultural production. Increased heat can also impact livestock operations negatively (lower weight gain and milk production as well as substantial losses in poultry operations)[44].

As temperatures increase beyond the 2-3 degree mark these high latitude regions will experience accelerated rates of warming intensifying more abrupt and extensive impacts on infrastructure, human health and local livelihoods, services and ecosystems.

3.3 REVIEW POLICY ENVIRONMENT AT SENIOR LEVELS OF GOVERNMENT

National and provincial government policies can have a profound impact on upper-tier municipalities such as the Region of Halton. For example, part of the impetus for the development of the Sustainable Halton Plan arose from changes in the Ontario government's policies, such as the "Places to Grow" initiative. Over the period covered by the DHP the Region will continue to be affected by and operate in the context of policies set by the national and provincial governments. This section is intended to provide an overview of the types of policies which may impact the DHP.

Recently concern over Climate Change has led a number of governments to announce plans aimed at achieving significant reductions in GHG emissions in the near and long term.

- The province of Quebec has set out a plan to reduce its GHG emissions by 6% below 1990 levels by 2020[45].
- The British Columbia government announced that intends to reduce GHG emissions to 33% below 1990 levels by 2020; bringing emissions to 10 per cent under 1990 levels.[46]
- California has set a target of reducing GHG emissions to 1990 levels by 2020 and to 80% below 1990 levels by 2050[47].

The Ontario government has also indicated that it is working on a Climate Change plan[48] though it has not yet prepared to discuss specific targets.

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[44] Kleinedist et al, 1993, Owensby et al, 1996, Kling et al, 2003).

[45] *Quebec and Climate Change: A Challenge for the Future, 2006-2012 Action Plan, Province of Quebec.*

[46] *Weather, Climate and The Future: B.C.'s PLAN, December 2004, British Columbia Ministry of Water, Land and Air Protection.*

[47] *California Environmental Protection Agency, Climate Action Team Report to Governor Schwarzenegger and the Legislature March 2006*.

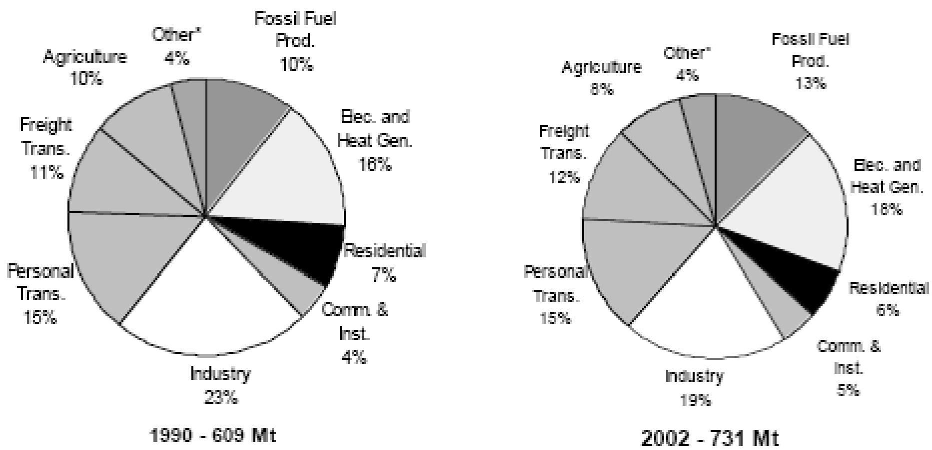
48 "Ontario aims to reduce greenhouse-gas emissions to 1990 levels: Province's climate-change policies said to match the best efforts in North America", Globe and Mail, February 20, 2007.

The federal government has introduced legislation, currently before the House, that outlines planned legislation to address both air quality and climate change issue. The federal Minister of the Environment has indicated that additional plans will be announced before the end of March.

While specific details are not yet available for the Ontario or federal government plans, we can speculate that they are likely to contain elements similar to those unveiled in other jurisdictions and that the targets for mitigation policies will ultimately be driven by the nature of Canada's and Ontario's GHG emissions.

At the national level, the energy sector (power generation and fossil fuel production) account for almost one-third of Canada's total emissions. Industry contributes another 20%, while transportation accounts for just over one quarter of emissions. While all sources of emissions will need to be addressed in order to achieve the type of deep reductions required to stabilize atmospheric CO2 levels, these are likely to be key areas of focus for national policies. Canada faces a particular challenge in controlling emissions from its oil and gas production, which grew from 10% of total emissions in 1990 to 13% in 2002; largely due to the growth in production from the oil sands.

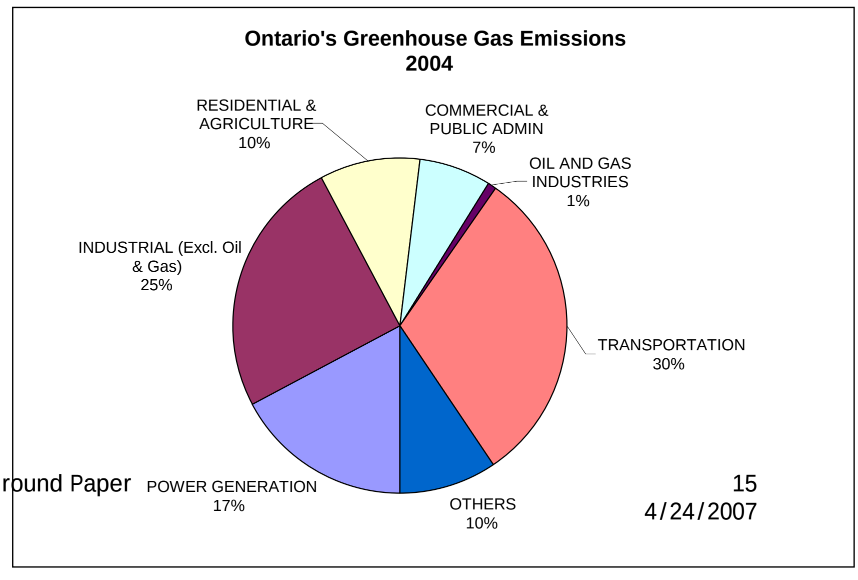
Figure 2: GHG emissions by sector in Canada, 1990 and 2002



Source: Canada's Greenhouse Gas Inventory, 1990-2002, Environment Canada.
*Waste, CH_4-related Land Use Change, and Forestry. CO_2 from Land Use Change not included, as per Canada's GHG Inventory.

Source: *Environment Canada, CANADA'S FOURTH NATIONAL REPORT ON CLIMATE CHANGE - Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change, 2006, figure 2.2.4.1, page 16*

By comparison Ontario's GHG emissions are dominated by transportation and the industrial sector. The province's electricity sector contributed 17% of emissions in 2004, however, the government's commitment to remove all coal-fired plants from service over the next seven years will largely eliminate



the power sector as a major source of emissions. This means that in order to make substantial progress in reducing emissions, policies will need to focus on the transportation sector, industrial emissions and to a lesser extent building energy use.

In order to stabilize global CO2 levels and limit climate change, deep reductions will be required in our fossil fuel use. Scenarios developed for the National Round Table on the Environment and the Economy (NRTEE) have demonstrated that such reductions can be achieved, largely with existing technology, however, this will require early action and a consistent policy commitment[49].

The options for reducing energy-related GHG emissions fall into a few broad categories: 1) improving energy efficiency or decreasing energy intensity; 2) reducing or eliminating energy use; or 3) substituting energy forms with lower carbon emissions.

- Efficiency is generally defined as allowing the same service to be performed while using less energy. The low emission scenario developed for Canada found that roughly 40% of the overall reduction in emissions could arise from energy efficiency[50].
- Increased energy intensity, measured in terms of energy use per dollar of economic output may increase due to energy efficiency or as a result of increased value added. Many Canadian industries have achieved significant reductions in energy use per $GDP by moving to higher value added products.
- Energy use can also be reduced or eliminated by doing less or eliminating processes that require energy . This may be the result of changing behaviour (ie. driving at lower speeds, turning down building temperatures, etc.) or by doing things differently (ie. holding meetings by phone, tele-commuting, reviewing information in electronic form rather than printing documents, etc.). In many cases, changes made for reasons quite entirely unrelated reasons have had significant effects on energy use.
- A move to lower emission energy sources may mean the substitution of other fossil fuels with lower carbon content, such as replacing coal with natural gas or gasoline with propane, or the complete elimination of fossil fuels through the use of renewables such as solar, wind, ethanol or bio-diesel.

GHG emissions from the industrial sector arise from both energy use and as a result of different processes particular to specific industries (ie. clinker production in the cement industry). Most jurisdictions have addressed these types of emissions through some form of a "cap and trade" arrangement. Under these arrangements, the regulator or government establishes a target level of emissions – or cap – which industries are not allowed to exceed. Industries which reduce their emissions below this level are allowed to sell the "credits" earned to other industries who use them to off-set their emissions in excess of their cap. Effectively this approach encourages the

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[49] The NRTEE "Advice on Long-term Strategy on Energy and Climate Change" was based on the findings from a low-emissions scenario developed by ICF International The scenario illustrated how Canada could achieve deep (60% below 1990) reductions in its GHG emissions. http://www.ieta.org/ieta/www/pages/getfile.php?docID=1722

[50] Ibid., page 1.

pursuit of the lowest cost opportunities first; providing an economically efficient approach to compliance.

The second key area that will be targeted by policies aimed at mitigating Climate Change is transportation. Policy targets are likely to include encouraging shifts to more efficient modes of transportation, for both passenger and freight transportation, increasing vehicle efficiency and "de-carbonization" of the fuel supply.

The move to encourage modal shifts may result in policies to encourage greater use of rail and mass transit. These could include policies to strengthen inter-modal connections, encourage higher densities to support mass transit, increased funding for mass transit or restrictions on the use of personal vehicles.

Vehicle efficiency is likely to be a key focus for both passenger and freight vehicles. California, for example, has mandated significant improvements in passenger vehicle efficiency which other jurisdictions may follow.

Policies are also likely to encourage consumers to choose more efficient vehicles. A review of new car ratings indicates that vehicle efficiency can vary by 30% or more within the same category of vehicle.

Lower carbon fuels and bio fuels are already being encouraged in many jurisdictions. In Ontario, as of 2007 all gasoline sold in the province must contain at least 5% ethanol. Requirements for ethanol and bio-diesel are likely to increase over time. California, for example, has set a goal of reducing the carbon content of fuel by 10% by 2020.

A third major challenge in reducing GHG emissions lies in improving the efficiency of energy use associated with buildings. Two thirds of the buildings that will be in use in 2050 are standing today. On one hand this means that a major effort will be required to retrofit existing structures to reduce their energy requirements. On the other it means that we still have an opportunity to influence decisions on one-third of that building stock. Decisions to increase housing densities can have a significant impact on the ultimate energy requirements of this new stock.

There are two other "non-energy" areas related to GHG emissions that are likely to be addressed by senior levels of government.

The methane emissions associated with landfills make a significant contribution to GHG emissions - in part because of methane's higher GWP (21x greater than CO2). Capturing and burning this gas is often one of the least expensive GHG reduction options; particularly when the resulting energy can be used to displace fossil fuels[51]. Recycling and other waste reduction programs can also make a significant contribution, both by reducing the quantities of landfill waste but by reducing energy required to process raw materials[52].

The final area expected to be a key focus in federal and provincial mitigation policies are carbon "sinks" such as agricultural and forested areas. Changes in forestry and land use practices can either release additional GHG gases or capture the carbon (also

[51] For example, the landfill gas generation plant developed by Oakville Hydro not only eliminates the release of methane gas but also helps to displace electricity generated from natural gas and coal.

[52] For example, paper made from de-inked, recycled fibre requires roughly 90% less energy than paper made from virgin materials.

referred to as sequestering). Typical efforts in this area involve tree planting efforts, sustaining agricultural areas or converting less productive land to forest, and changes to agricultural practices to increase the amount of carbon captured in the soil.

Municipalities such as the Region of Halton have a significant influence over some of the key long cycle drivers of energy use. Decisions on housing densities, for example, will influence future building energy requirements, transportation options, and the energy required to deliver water, waste water and waste collection services.

3.4 REVIEW OF SUSTAINABLE HALTON REPORTS

Climate change may have significant consequences and impact costs on several areas of municipal responsibility. While we have primarily focused on planning related issues, planning systems will need to be flexible to respond to this and policy responses should be integrated across departments to reflect this complexity. Economic policy, social policy, health policy, transportation policy, and emergency planning will all be affected. Municipal governance structures will need to adjust to identify these links and synergies in order to respond most effectively. As an upper tier municipality Halton will need to work with local governments to address these impacts.

In general, designing regional and local Official Plans to accommodate and prioritize sustainable development practices can play a significant role in enabling mitigation strategies widely.

Across North America, municipalities have taken the lead in acting on climate change policy. Cities and States have recognized their significant risk exposure and as a result a number of states and cities have embarked on progressive climate action plans to identify mitigation opportunities and adaptation options.

Planning issues addressed in the background reports for the Sustainable Halton Plan have implications both for future levels of GHG emissions and for the Region's ability to adapt to future changes resulting from climate change. Some key mitigation and adaptation considerations for planning in Halton region are discussed below. While the following list is not exhaustive, it has been developed by reviewing the DHP papers and extracting relevant policy recommendations and supplemented by our knowledge of climate change impacts relevant to Halton Region's. The strategies have been grouped into 5 main planning categories to facilitate the analysis and initiate discussion on potential policy measures.

3.4.1 Planning area: Transport

The 2006 census indicates that while the environment is a key concern for Canadians, the trend of urban sprawl and car dependent community growth continues across the country. Therefore, the transportation sector will continue to represent a key target for GHG emission reduction strategies. Beyond personal transportation use, maintenance of reliable and functional transportation networks will be key to ensuring undisrupted movement of goods to and from the region. Transportation policies targeted at more sustainable modes offer significant potential to mitigate future emissions. Building on the DHP reports in this area, some recommendations include:

Mitigation

- Supporting urban intensification efforts that are presented in the DHP papers creates the economic conditions necessary to enhance and expand public transportation networks.
  - In addition to overall expansion of public transportation routes, etc., mentioned in the DHP Transportation report, policies should be designed to encourage increasing the sustainability of these fleets, for example hybrid buses.
  - Intensification can also encourage non-auto modes of transportation such as walking and cycling (so called "walkable" communities). Increasing walking and cycling in the region also supports the air quality and health initiatives presented in the DHP reports.
- Supporting businesses that encourage flexible work weeks, telecommuting, or teleconferencing for meetings to reduce overall travel requirements or at least facilitate off peak travel.
- Encouraging the use of alternative or low carbon fuels in all modes of travel including personal, freight, and agricultural equipment and vehicles.
- Supporting the continued expansion of public transit on heavy east-west commuter routes that link the regions communities within and to the GTA.
  - As presented in the DHP Transportation paper, integration of regional transit systems could be linked to the Province's goal of developing a Greater Toronto Transit Authority to coordinate the effort. Interregional Fare Card Systems, expansion of GO, and consideration of a ferry link between St. Catherine's Hamilton, Mississauga, Pickering and Oshawa can support this target.
- New highway and road development should be built with the goal of including and encouraging more sustainable modes of transportation, cycling lanes, rapid transit bus lanes, car pool/multi-occupant vehicle lanes, etc.
  - As encouraged in the region's current Official Plan, continued efforts to develop a Inter-Regional Transit Network and identifying primary and secondary transit nodes as well as priority transit transfer centers will help increase the share of public transit being developed to meet the region's transportation capacity needs.

Adaptation

- In addition to the requisite upgrades and expansion of transportation infrastructure identified in the DHP papers, municipal budgets and departments should anticipate increasing needs for increased future maintenance as CC impacts degrade roads (heaving and cracking, as well as damage from extreme weather events) and other infrastructure. This will reduce the risks associated with disruption to the transportation of goods and equipment, import of food stuffs and necessities or travel. This increase in costs may be somewhat offset by lower snow clearing and other costs due to milder winters.

3.4.2 Planning Area: Agricultural, Natural Heritage Systems, and Aggregates

Planning to accommodate the scale of population growth that has been identified for the Greater Golden Horseshoe Region in the Province's *Places to Grow* report will require changes in land use designation. This shift presents challenges for planners and decision makers who will have to choose which land uses to preserve and which to designate for development. Preserving prime natural heritage, countryside and agricultural land areas is an important issue not only to maintain ecological systems, recreational uses and rural economies but is also central to a regional climate response. The DHP papers address this tension and identify policies and priority areas to be considered when allocating where development will be permitted. These policy recommendations can contribute to the effectiveness of a regional climate mitigation plan and adaptation strategies by preserving the quantity and quality of agricultural and natural heritage land in the region. These areas can act as carbon sinks, absorb some impacts of severe weather events, and provide more flexibility for natural systems to respond to change. Policies will also need to consider the impacts of climate change on these land uses and local economies and how best to reduce this risk and adapt in the future.

Mitigation

- The DHP papers emphasize the need to preserve prime and specialty crop lands from development.
    - The DHP Agricultural report notes that there are significant prime and specialty lands in the primary study area that are under consideration by the province for development[53]. The region will need to address how to protect these lands both as quality natural spaces and for their economic value, while simultaneously accommodating growth. As the quantity of green spaces and agricultural land is decreased in the region, the value of the remaining areas in mitigating climate change increases, as well as their role in sustaining the rural economy. Designating land for development today should be done with consideration to how climate change impacts might impact the land productivity across the region in the future.
    - Consideration should be given to ensuring that other uses such as rural estates, waste disposal sites and golf courses are located on the less productive lands.
- The DHP Food security report's recommendation to develop policies that support local food security through a stronger relationship between local producer and consumer can also contribute to the regions mitigation effort. Encouraging consumers to "buy local first" can reduce the emissions associated with transporting food into the region, support and reward local farmer's sustainability initiatives (such as investments new crops, no/low till practices etc.) while also making the region less susceptible to possible disruptions in supply from other areas impacted by climate change.
- In addition to the traditional food crops, encouraging the development of new crops such bio-fuels and "nutraceuticals" (as noted in the DHP reports), can diversify the region's agricultural base and plant species; reducing the risk of major disruptions to agricultural production as a result of climate impacts (such as infestation or disease).
- Encouraging the development of bio-fuels can contribute reducing the carbon content of the region's transportation activities and reduce the risk of supply disruptions.
- Reducing the quantity of agricultural fertilizers used in local operations (cash crops, fruit and vegetable producers, nutraceuticals, etcetera) will reduce the

[53] The DHP Agricultural report notes that most of the land protected in the Greenbelt legislation is not considered prime land, which tends to be located in the currently areas zoned for development.

release of nitrous oxides. Crop management and rotation techniques can contribute to this effort.

- Implementing no/low tillage practices in appropriate agricultural crops can reduce GHG emissions as well as increase the ability of the soil to capture and store GHGs.
- Supporting manure management technologies and practices can help reduce emissions form regional livestock operations. Biogas technologies can contribute to reducing emissions by both limiting the methane emissions and reducing local energy needs through on-site renewable generation.
- Promoting urban agriculture where appropriate can increase local food security and reduce the emissions related to food transportation and cultivation.
  - Urban agriculture increases the green space in settlements which reduces urban heat island affect, improves air quality and filters/absorbs storm-water which minimizes the pressure for water treatment infrastructure required to manage storm-water runoff from impermeable urban surfaces.
- Increasing green spaces and tree canopy in urban areas, as presented in the DHP Healthy Communities paper:
  - Contributes to an urban cooling affect mitigating the impacts of increase extreme heat events.
  - Simultaneously acts as an additional carbon sink for the region.
- Supporting educational programs identifying opportunities for landowners to plant native species in urban and rural areas can increase the amount of appropriate, available, and permanent habitat for migrating and local species.
- The DHP Natural Heritage paper encourages preserving and enhancing all natural connections that sustain the NH area. Developing policies to guide and maintain these important natural connections and services will play an important role in climate change mitigation and adaptation. These connections can aid in preserving the integrity of ecosystems by 1) ensuring ground water systems remain linked to support wetlands and 2) allowing the movement of flora and fauna as they move in response to climate change.
- Supporting the development of natural heritage lands including woodlands and grasslands will allow them to act as regional carbon sinks.
- As presented in the DHP papers, natural areas should be managed with an ecosystem based approach rather than a features based approach to maximize the outcome which will also contribute positively to climate change mitigation and adaptation efforts.
- In areas where aggregate development competes with land that could also be used as natural heritage lands, prime agricultural lands or as key corridor or buffer zones, the full impacts of losing those green lands should be carefully considered.
- Rehabilitating decommissioned aggregate sites can provide an opportunity to convert the land to uses which will result in increased carbon sequestration.
- Protection of natural lakeshore and wetlands should be given a high priority as these areas will be stressed by declining lake levels. Such areas can provide a valuable service not only as water filtration and wildlife areas but in absorbing the impact of severe weather events.

Adaptation

- Support the introduction of select high value production crops to ensure economic growth/stability in agricultural areas to reduce impact of shorter or changing productivity

- Reduce development on prime and specialty agricultural lands that have the highest productivity potential.
  - As noted earlier, the targeted growth area in Halton overlaps with much of the regions prime agricultural land.
  - Prime agricultural land can support the production of higher value specialty crops (such as vineyards or organic crops) both as cash crops and as local food security crops. The type of crops that can be grown in the area will change as growing degree days increase in the coming decades.
- Plan for natural corridors to accommodate movement of plants and animals as territories/habitats change
- Encourage and implement programs to plant native species that can enhance local habitat and be used to for control invasive species in crop management.
- Design programs to monitor and inventory indicators to ecosystems well being, as well as declining or vulnerable populations. Such initiatives can help protect natural systems and direct adaptation strategies to high risk areas.
- Plan and protect strategic agricultural, wetland and other countryside natural area land uses to provide buffer zones for natural heritage areas.
  - These land uses act as buffers to protect vulnerable species and populations from shocks such as severe weather impacts as well as facilitate necessary migration.
  - Reduces fragmentation of habitats and supports the provincial greenbelt corridor.
- Short and long term regional pest and disease management plans can identify risks and recommend new practices to reduce impacts of infestations.
- Support local crop diversification based on crops that are better suited to new climate conditions, are resilient to seasonal shifts and severe weather, require less water and fertilizers.
  - Diversifying the selection of crops in the region will reduce the risk of infestations and major regional economic losses.
  - Crops with lower water and irrigation requirements can relieve pressure on water supply during the summer peak. New irrigation technologies and techniques can also be supported.
  - Supporting specific local food crops can ensure regional agricultural lands contribute to local food security, and maintain access to affordable and nutritional food staples.

3.4.3 Planning area: Housing and Economic Growth

The form of housing development and economic growth in a region directly influences the community's ecological footprint by determining the quantity and character of inputs required to sustain the community. Since energy use contributes such a large share of GHG emissions, housing and economic policies are essential to the region's climate change response. As discussed earlier, not only will economies be required to adapt to climate change impacts, but housing and economic planning presents a significant opportunity to mitigate climate change in the region.

Mitigation

- As discussed in the DHP Energy, Intensification and Housing papers, continue to plan for, and accommodate, higher density growth which reduces energy demand both in terms of transportation (public transportation and non-auto modes) as well as building energy demands.

- As recommended in the DHP Human Services paper, continue to prioritize planning complete service neighbourhoods which include high density residential units and increased access to basic amenities (i.e. local shopping, groceries, parks) and opportunities for local employment to reduce transportation needs.
- Plan for location of economic lands in close proximity to transportation corridors – particularly to Intermodal sites – to encourage the use of more efficient modes where possible.
- Building codes and permits can include requirements for energy efficiency standards.
- Ensure that affordable housing developments prioritize efficient design and appliances.
- Support the existing industry efforts to reduce energy use per dollar of output and to decrease their non-energy emissions through the adoption of new process and capture technologies.

Adaptation

- Building codes and permits should consider structural and other requirements to withstand more severe weather events (ie. preventing back flow from storm water systems).
- Consider policies to encourage upgrading and retrofitting existing buildings to withstand more severe weather.
- Encourage green roofs and other opportunities to incorporate naturalized areas in new and existing structures.

3.4.4 Planning Area: Infrastructure Services

Community development, intensification and growth all require a significant amount of infrastructure development to provide access to basic needs and services. Given that the planning, development, operation and maintenance of this infrastructure is centralized through the utilities or municipal government departments, the following infrastructure areas present considerable opportunities to implement policies that will reduce the regions GHG emissions. Long term investments in infrastructure should also consider future climate risks.

Waste Management

Waste management includes: landfills, composting sites, recycling facilities and drop offs, and waste to energy facilities.

Mitigation

- Continue existing waste reduction/diversion programs and goals that are articulated in the Official Plan and plan to increase diversion rates. The Official Plan states that the region should "regard waste as a resource in transition waiting to be reclaimed and for which re-use or alternative uses are available and desirable"[54].

[54] Official Plan A5a1 cited in the waste paper.

- Diverting organics (including food, yard and agricultural wastes) from landfills can significantly reduce the associated GHG emissions by capturing the methane to generate electricity and/or heat. These biogas and landfill gas energy generation technologies also simultaneously generate electricity and heat which further displaces more carbon intensive sources.
- The outputs of food composting depends on the processing method, for example aerobic composting produces CO2 (i.e. Halton Green Bin) and anerobic composting produces methane that can be captured to produce heat and electicity.
- Diverting waste products to recycling will reduce waste volumes collected; extending the life of the existing landfill and allowing more of Halton's non-settled area to be designated as agricultural, natural heritage and countryside land uses which each contribute to reducing the impacts of climate change in the region as discussed above.
- As recommended in the DHP discussion paper on Waste Management, waste-to-energy generation technologies being considered can displace higher carbon emission electricity generation and divert waste from landfills.

Water, Waste Water, Storm Water and Storm Water Management

Water and waste water infrastructure includes: drinking water supply treatment and distribution, waste water collection and treatment and storm water management.

Mitigation

- Biogas generation technologies can be applied at waste water treatment sites. These technologies capture the methane gas emissions and generate electricity and/or heat (possibly also displacing GHG-generating electricity supply).
- Expand the recommendation of continued partnering with the agricultural community to manage the regions biosolids. The use of residual bio-solids from waste water treatment can be used to displace demand for fertilizers, reducing associated nitrogen emissions.
- Continue to implement comprehensive watershed management plans that identify, monitor and protect regional water resources.
  - Local zoning policy and permitting can be designed to support these goals and protect regional water supplies.
  - This is complimentary to the Source Protection plans recommended in the DHP Waste and Wastewater reports.
- Integrate climate change impact analyses into Environmental Assessments for water projects. The DHP Water and Wastewater Infrastructure paper identifies the need to increase the capacity of regional water treatment, and distribution systems. Changing hydrological cycles and the impact of this development on the local water resources should be carefully evaluated. Extended drought periods could have a significant impact on peak water demands and water storage requirements.
- Incorporate conservation and demand management options in water supply planning.

Adaptation

- Plan to upgrade and build storm and waste water drainage and treatment infrastructure to respond effectively to increased winter/spring flooding and heavy precipitation events.
- Review design standards used for storm water and wastewater systems to take into account the expected increase in frequency and severity for severe weather events.
- Planning should also consider the impact of increased precipitation and flood events on the region's ability to discharge the required volumes of tertiary treated waste water into streams that are at, approaching, or over capacity.
- Plan growth areas to include and increase the overall coverage of permeable surfaces in developed areas to absorb and reduce the amount of surface runoff during increased precipitation events, early snow pack thaw, etc..
- Support programs to reduce overall regional water demand to reduce impact during water shortages, for example low flow water devices, water efficient design, rain barrels for yard maintenance activities, and awareness and information campaigns.
- Planning should consider the impact of lower water levels in the region's lakes as well as diminished ground water aquifers on well water systems and lake water purification plants, particularly during the drier summer months Higher costs to supply water due to higher peak flows during these drought periods.
- Developing a connection to neighboring regional water systems might be considered to reduce the risk to Halton's overall water supply and treatment system.
- The construction of new major trunk water mains, feeder-pipes and reservoirs to increase access to alternate water supply sources are also being considered and reviewed in the region.

Energy Supply

Energy supply infrastructure includes systems for transmitting and distributing natural gas, electricity and transportation fuels. The facilities for creating or extracting these supplies are predominantly located outside of the Region, with the exception of some local power generation. In future, district heating and cooling systems could be added to this infrastructure. In general, the Region of Halton has greater potential to affect energy demand than energy supply decisions, however, there are some areas where Regional policies can influence supply infrastructure.

Mitigation

- Support for the development of distributed and combined heat and power generation (co-generation) where feasible to both reduce GHG emissions and increase diversity and resiliency of the local power system.
- Much of the local power distribution system in the Region is now underground, which helps to reduce the risk of infrastructure damage during severe weather events. Utilities should be encouraged to identify areas where system vulnerability to severe weather events can be further improved.
- Energy demand issues:
    - Support shifts to more efficient building design, equipment and appliances to reduce the overall energy use in the area and the associated GHG emissions.
    - Support a shift to low carbon fuels for heating and transportation, particularly within the Region's own operations.

    - Implement biogas and landfill gas capture technologies in the region as discussed above.
    - Encourage local distribution companies to invest in Conservation and Demand Management activities, including efforts to reduce line losses in their own systems.
- Support the development of district heating and cooling systems where increased densities permit.
- Investigate the use of deep water cooling in high density development areas near Lake Ontario.

Adaptation

- Planning local electricity transmission and distribution grids to support and encourage distributed generation will reduce the risk of power outages across the region and reduce the overall area affected by service disruptions.
- Review Emergency Preparedness Plans to anticipate how to respond to severe weather events which result in extensive or lengthy service disruptions.
    - The costs associated with repair to weather damaged transmission and generation facilities from increased severe weather events should be considered in local budgeting as well as the impact that such increases may have on retail prices and affordability.

Planning Area: Public Services

Access to essential community services is an integral part of building the complete communities as advocated in the DHP Housing papers. These services are designed to maintain and increase local quality of life. The agencies and services can and will play a central role in mitigating, educating and providing support for CC impacts. Opportunities to partner and share resources and experiences between agencies within the region should be maximized. Expanding these service areas as integrated hubs within the region will support efforts to maintain access to health care, community/social services, education, policy, housing etcetera, while also creating environments to support and implement community-wide climate mitigation and adaptation responses.

Mitigation

- Schools and Institutions should be encouraged to improve public education on climate change and provide practical advice on how individuals and businesses can do their part in reducing emissions.
    - Utilize the skills and characteristics of schools and academic institutions to be sites of community climate change educational programs, employment retraining and certification to build capacity in areas that will be required in our response to CC, or sites for sustainable energy project demonstrations for example.

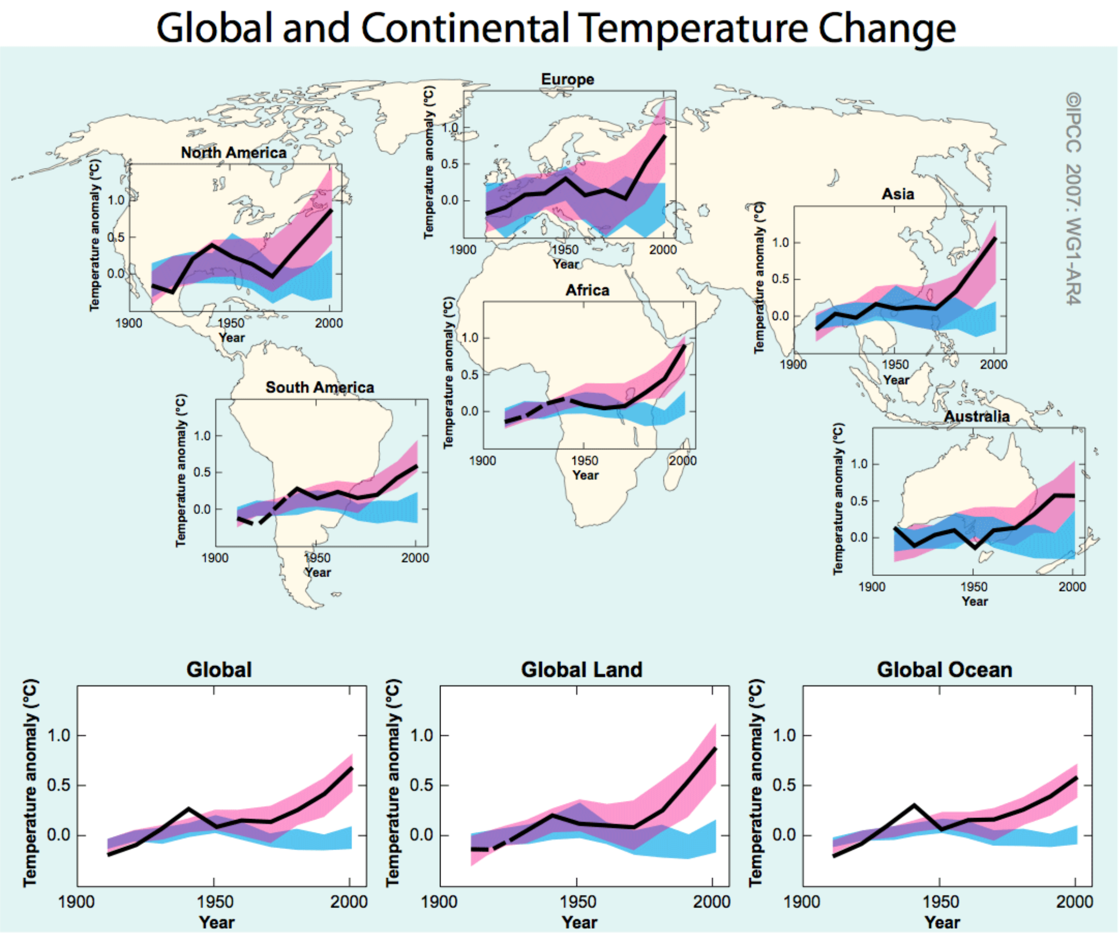
Adaptation

- Health care services
    - Incorporate weather events and other potential CC related events in Emergency Preparedness Planning exercises.
    - Plan for increased emergency room and hospital capacity to respond to extreme heat event health impacts, water and vector borne disease occurrences, poor air quality, and extreme weather impacts

- Planning to utilize community and public buildings as cooling centres/shelters during extreme heat events for all residents. These response strategies can be designed to target groups that have limited access to cool areas or are a higher health risk (elderly, homeless, low-income, youth).
- Design advisory campaigns to alert community members of occurrences of high risk days (news casts, community services announcements, targeted list serves).

- Community Support
  - Emergency response planning should consider the role and coordination of Police, Fire and Emergency Response services that will be required to respond in extreme weather event

APPENDIX A: GLOBAL AND CONTINENTAL TEMPERATURE CHANGE



Source: http://blog.sciam.com/media/SPM-4_plenarydraft.gif

APPENDIX B : GWP AND ATMOSPHERIC LIFETIMES

TABLE 1-1: Global Warming Potentials and Atmospheric Lifetimes

GHG	Formula	100-Year GWP	Atmospheric Lifetime *(years)*
Carbon Dioxide	CO_2	1	Variable
Methane	CH_4	21	12 ± 3
Nitrous Oxide	N_2O	310	120
Sulphur Hexafluoride	SF_6	23 900	3 200
Hydrofluorocarbons (HFCs)			
HFC-23	CHF_3	11 700	264
HFC-32	CH_2F_2	650	5.6
HFC-41	CH_3F	150	3.7
HFC-43-10mee	$C_5H_2F_{10}$	1 300	17.1
HFC-125	C_2HF_5	2 800	32.6
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1 000	10.6
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1 300	14.6
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300	1.5
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3 800	3.8
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140	48.3
HFC-227ea	C_3HF_7	2 900	36.5
HFC-236fa	$C_3H_2F_6$	6 300	209
HFC-245ca	$C_3H_3F_5$	560	6.6
Perfluorocarbons (PFCs)			
Perfluoromethane	CF_4	6 500	50 000
Perfluoroethane	C_2F_6	9 200	10 000
Perfluoropropane	C_3F_8	7 000	2 600
Perfluorobutane	C_4F_{10}	7 000	2 600
Perfluorocyclobutane	c-C_4F_8	8 700	3 200
Perfluoropentane	C_5F_{12}	7 500	4 100
Perfluorohexane	C_6F_{14}	7 400	3 200

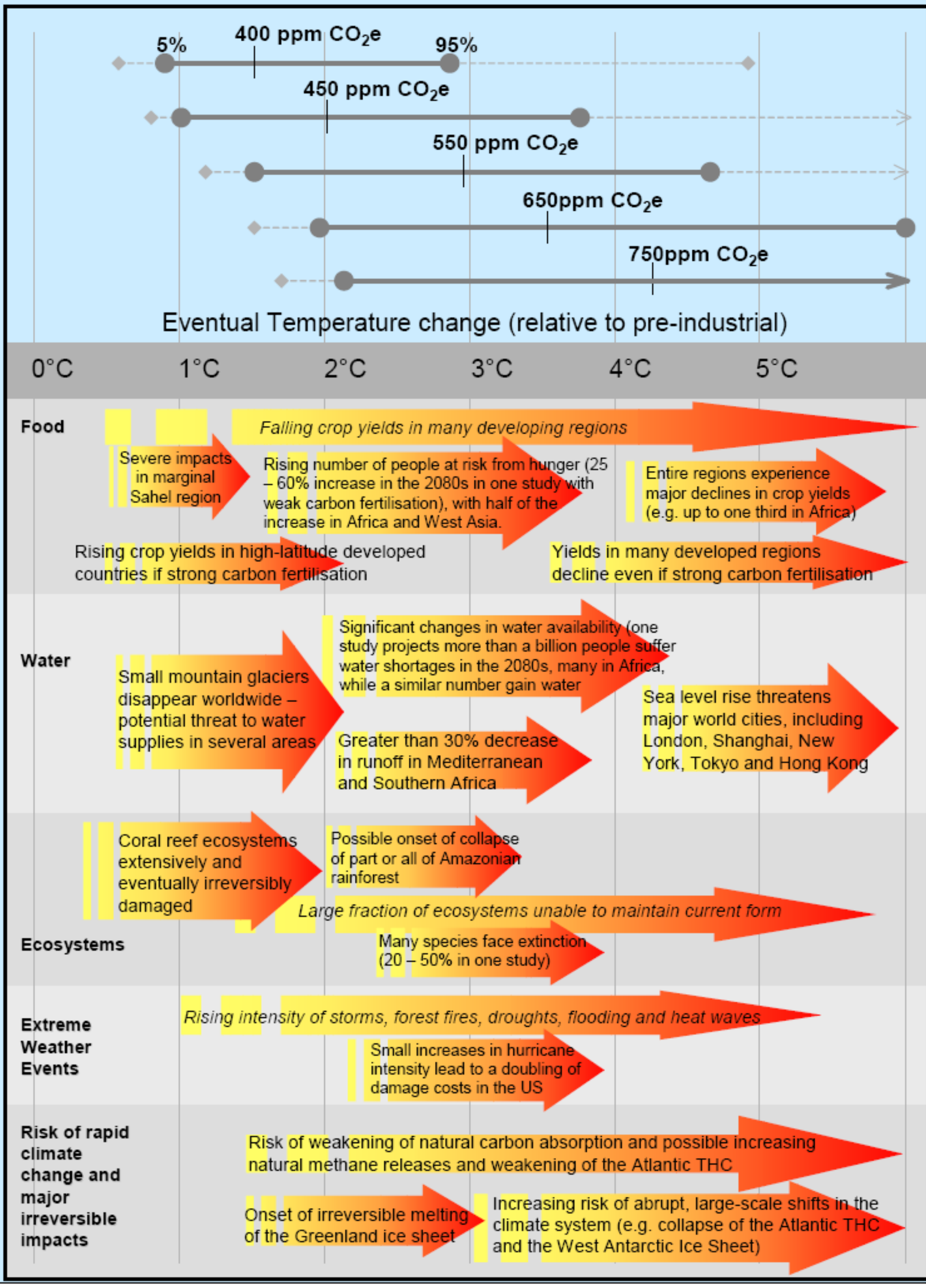
Note: The CH_4 GWP includes the direct effect and those indirect effects due to the production of tropospheric ozone and stratospheric water vapour. Not included is the indirect effect due to the production of CO_2.

Source: 2006(b), NRCan.

APPENDIX C: CO2 CONCENTRATIONS AND TEMPERATURE CHANGE

Figure 2 Stabilisation levels and probability ranges for temperature increases

The figure below illustrates the types of impacts that could be experienced as the world comes into equilibrium with more greenhouse gases. The top panel shows the range of temperatures projected at stabilisation levels between 400ppm and 750ppm CO_2e at equilibrium. The solid horizontal lines indicate the 5 - 95% range based on climate sensitivity estimates from the IPCC 2001[2] and a recent Hadley Centre ensemble study[3]. The vertical line indicates the mean of the 50th percentile point. The dashed lines show the 5 - 95% range based on eleven recent studies[4]. The bottom panel illustrates the range of impacts expected at different levels of warming. The relationship between global average temperature changes and regional climate changes is very uncertain, especially with regard to changes in precipitation (see Box 4.2). This figure shows potential changes based on current scientific literature.



Source : 2006, Stern.

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