Trends in Kingston's Community Greenhouse Gas Emissions (2000-2006)

A working paper by Ted Hsu for the KEAF PCP working group
Version: Nov. 23, 2007

Acknowledgements

It would have been impossible to do this study without free help from many people and institutions. **Paul Maclatchy** (**City of Kingston**) and **Beth Sills** (**TriEdge – Research and Consulting**) took the time to provide many important documents and helpful guidance concerning the history of Kingston's participation in the PCP program, and the year 2000 baseline study. **Utilities Kingston** (**Ken Mundell**, **Steve Sottile**, and **Nancy Taylor**), provided aggregate monthly data from 2000 to 2006 on electricity use, natural gas use, number of customers, heating degree days, and cooling degree days. They also educated me on the importance of weather data. **Doug Barnard** of **IESO** customer relations provided information about the Ontario Energy Generation mix from 2004-2006. **Hydro One Networks** (**Kelly Kingsley** and **Mike Della Rossa**) provided aggregate monthly data for 2003 to 2006 on electricity usage by residential, commercial, and agricultural customers. **Union Gas** (**Bernie Huisman** and **Danny Watson**) provided aggregate annual natural gas usage by general service and contract customers for the years 2003 to 2006. **Waste Management** (**Wes Muir**, corporate communications) provided information on methane flaring at the Richmond landfill and upstate New York landfills and the absence of their use for carbon offset trading. **John Giles** of the City of Kingston provided information about solid waste. **Superior Propane** (**Steve Barber**) provided a rough estimate of how much propane used has changed in Kingston since the year 2000. **Rosen Fuels** (**Adam Koven**) provided an estimate on how much consumption of heating oil in Kingston has changed since the year 2000.

About the Author

The author was trained as a research physicist (PhD, Princeton, 1989) and is author or co-author of 25 research publications. He has worked as a Killam postdoctoral fellow at the University of British Columbia; at the *Centre National de la Recherche Scientifique*, Grenoble, France; and Chalk River Laboratories, Atomic Energy of Canada.

Executive Summary

In 2004, the City of Kingston set a community greenhouse gas emissions target of 10% below year 2000 levels by the year 2014. Having a target and undertaking serious efforts to achieve it are important because global warming is a "tragedy of the commons" problem. In order to solve such a problem, everybody has to cooperate and to be seen to contribute to the solution. Unfortunately, initial suggestions were that emissions cuts of one-quarter from business-as-usual projections would be required – a very difficult to achieve goal.

In this paper we report the results of an effort to monitor how Kingston's greenhouse gas emissions have changed, year to year, over the period 2000 to 2006. The details of the methodology are given in order to aid those who would wish to update Kingston's greenhouse gas inventory in the future. An estimate of Kingston's greenhouse gas emissions is given for each year from 2000 to 2006, and each of the main sources of greenhouse gases is analyzed in turn.

Kingston's greenhouse gas emissions appear to have decreased by about 9% from the year 2000 to the year 2006. The main contributions to this are (i) a reduced contribution of coal to Ontario's electricity generation mix, (ii) reduced natural gas use because of warmer winters, and (iii) only modest growth in gasoline consumption. While there are still 7 years of potential population and economic growth until the target year, 2014, Kingston's greenhouse gas emissions reduction target is now, with some effort, realistically achievable.

Most of the reductions have been caused by factors outside our direct control. So far in the data there are suggestions of, but no clearly identified results from efforts by Kingstonians to reduce energy use. From now until 2014 it will be important that we are seen to be achieving this target *because* of our efforts and not in spite of our inaction. This goes back to the idea of fostering cooperation to solve a global problem that is of the "tragedy of the commons" type.

Because the emissions reduction target is now realistically achievable, it would be worth publicizing the emissions target, pursuing it with a local action plan, and monitoring progress through continual updates to the results of this paper. Trying to achieve a realistically attainable target may provide some drama and attract the interest of the public. The public can and must make the difference in achieving the target and 'real-time' monitoring of this target may remind them and motivate them to act, and show them what they have achieved.

Introduction

Climate Change

Canada is a major contributor to global warming on a per capita basis

Emissions of carbon dioxide (CO_2) and other gases, collectively called Greenhouse Gases (GHGs), from human activity are causing a warming of the earth's surface. This 'Global Warming', occurring very rapidly on geological timescales, will cause climate changes that will impose huge costs on human societies[1]. The main source of GHG emissions is the use of fossil fuel by industrialized societies. On a *per capita* basis, Canada is a significant contributor to this global problem[2]. This paper reports the time variation of GHG emissions by the community of Kingston, Ontario, Canada over the years 2000 to 2006, and explains how these emissions were calculated.

Tragedy of the Commons

Global warming is a "tragedy of the commons" type of problem

The problem of GHG emissions causing global warming is a type of problem referred to as a "tragedy of the commons". In this case when one person emits greenhouse gases for free into the atmosphere, he/she benefits but everybody else pays. When somebody makes an effort to reduce emissions of greenhouse gases, he/she pays the cost, but everybody else benefits. If one looks at this problem only from one's own point of view one could rationally argue that it is not worth doing anything. Indeed some have tried to say just that based on the argument that any reductions in GHG emissions by Canada would be dwarfed by emissions increases in developing countries.

Usefulness of Targets: fostering cooperation

If we show that we are doing our share, others will more likely do their part

To solve this problem it is important that as many people as possible get together and agree to share the burden fairly, and that each person can verify that others are doing their part. In that spirit the Kyoto protocol[3] was developed with definite targets and timelines for GHG emissions reductions by those industrialized countries that have benefited from emitting the current excess CO_2 in our atmosphere. The Kyoto targets were a modest first step intended to foster the international cooperation necessary to pay the costs to deal with global warming. A greenhouse gas emissions target for the Kingston community would demonstrate to other communities that Kingston is committed to do its part. If other communities can trust that we are doing our fair share of the work, they will be more likely to make an effort themselves.

Partners for Climate Protection

Kingston has joined a program of the Federation of Canadian Municipalities to reduce GHG emissions

---

[1] See, for example, the *Stern Review Report on the Economics of Climate Change*, Nicholas Stern, for HM Treasury, United Kingdom, October 2006.

[2] In 2003 Canada had the third highest GHG emissions *per capita* out of 30 OECD countries, below only the United States and Luxembourg.

[3] *The Kyoto Protocol to the United Nations Framework Convention on Climate Change*, United Nations, 1998.

In the year 2001, Kingston City Council decided to endorse the City's becoming a member of the Federation of Canadian Municipalities "Partners for Climate Protection" (PCP) program[6]. Participating municipalities undertake to achieve the following five milestones of the PCP program:

1. Establish a Greenhouse gas inventory
2. Establish a target for emissions
3. Make a Local Action Plan (LAP)
4. Implement the LAP
5. Monitor, verify, and report

Milestone 1 was achieved in 2003[10,4] and presented to City Council in 2004[6].
Milestone 2 was achieved on June 22, 2004 by a motion of City Council[8].

Kingston's Target

Our target is to reduce GHG emissions to 10% below year 2000 levels by 2014

On June 22, 2004, the City's environmental engineer[5], made a presentation to City Council[6] including, among other things, the PCP program, data on Kingston's GHG emissions, and a recommended emissions target. City Council then resolved to develop corporate and community action plans, in accordance with the PCP program, that would achieve GHG emission reduction targets of 25% for the Corporation and 10% for the community, below year 2000[7] baseline levels, by the year 2014[8]. Throughout the rest of this report we will be concerned with GHG emissions by the community and not the Corporation.

In 2005 the City of Kingston ran an extensive awareness campaign by being chosen as one of the municipalities to run a pilot project for the federal government's One-Tonne Challenge program. This program was cancelled in 2006 after the change in government. At the time of this writing the Kingston Environmental Advisory Forum is undertaking the development of the LAP, milestone 3 of the PCP program[9].

For a few reasons, now is a good time to review how Kingston's greenhouse gas emissions have changed. Firstly, before putting together the LAP, it will help to know what range of the expected emissions is for the year 2014. Secondly, and this was an important lesson learned from compiling the data for this report, it is difficult to get records for more than a few years back. Postponing the analysis may lead to a loss of information. That is why the year 2000 was chosen as a baseline for the PCP program and not the year 1990 (as used by the Kyoto protocol). Companies and government ministries change data storage hardware, software, or formats. Methodologies for extracting data in one year may not be possible in a later year. Lastly, it may be possible

---

[4] City of Kingston: Corporate Emissions Inventory, ICLEI Energy Services, Sept. 11, 2003, prepared for the City of Kingston
[5] Beth Sills
[6] City of Kingston, Report to Council No. 04-006
[7] The year 2000 was chosen because data were available to make a proper baseline assessment.
[8] Kingston City Council Meeting No. 19, Minutes, page 413, June 22, 2004.
[9] A previously proposed plan was based on a consultant's report that contained a serious conceptual error.

to inspire people by tracking progress towards GHG emissions reductions or the lack of it. Ideally, although it's very difficult to do this in practice, one would like to sort out what changes in GHG emissions were a result of Kingstonians' efforts and what were a result of factors outside our control.

Original 2000 baseline GHG inventory

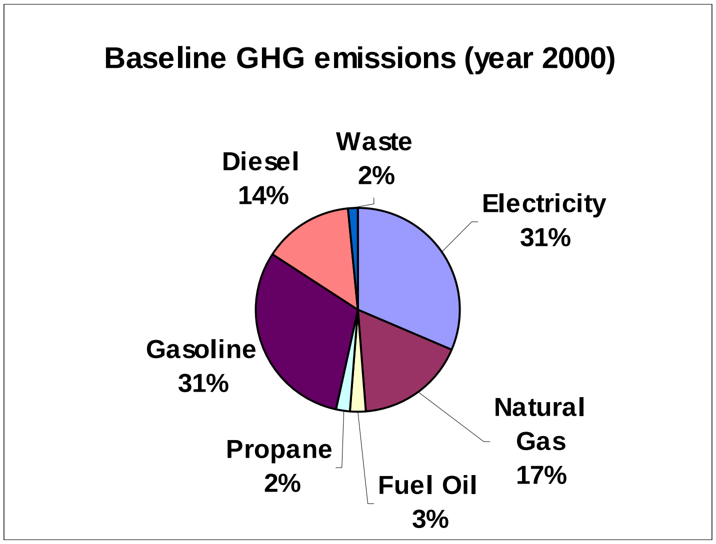
Kingston was responsible for emitting about 1.4 M tonnes of CO_2 in 2000. The calculation methodology used to get that number is hard to extend forward in time. This work uses a different methodology for certain items.

The original Community Greenhouse Gas year 2000 baseline inventory was determined in 2003 to be as follows[10]:

Table 1

Source	**Emissions (kt CO_2)**
Electricity	430
Natural Gas	237
Fuel Oil	39
Propane	31
Gasoline	427
Diesel	194
Waste in Landfills	25
Total	**1385**

Figure 1



[10] City of Kingston: Community Emissions Inventory, ICLEI Energy Services, Sept. 11, 2003, prepared for the City of Kingston.

The targeted 10% reduction in GHG emissions is the equivalent of cutting 140,000 tonnes of emissions. To put this in perspective, it is roughly the emissions from one year's worth of 20km roundtrip automobile commutes by 10,000 workers.

We would like to see how Kingston's GHG emissions have changed since the year 2000. Unfortunately the methodology chosen for the baseline methodology is difficult to extend to later years. There is a need for a new methodology to be able to track time dependence. This new methodology does not necessarily need to give an accurate value for absolute levels of emissions. For example, in the original baseline study, motor fuel usage was estimated from the City of Kingston transportation model, population and employment data and average vehicle fuel economy. It would be complicated to update all of these inputs over time. In the new methodology of the present study, quarterly retail gasoline sales data for the City of Kingston was purchased for the years 2000-2006. Assumptions were made about the corresponding diesel fuel use using data from the annually published *Canadian Vehicle Survey*.

Expected Increase in GHG emissions

Kingston's business as usual GHG emissions could go up by 0.5% to 1.0% per year

At first glance, one might expect that Kingston's Community GHG emissions target would be very difficult to meet. The ICLEI report on baseline emissions stated that Kingston's population was expected to grow at 1.4% per year[10]. This number is at the high end of projections contained in a Kingston Economic Development Corporation report[11]. If growth occurred at this rate over 14 years, and GHG emissions rose proportional to population, then the 10% below year 2000 target would represent a 26% below business as usual (BAU) reduction. Getting people to reduce energy use by one-quarter is quite a non-trivial task.

With the 2006 census results, unavailable at the time of the GHG baseline study in 2003, we can see that the actual growth in population has been less than expected: only about 0.5% per year. This rate of growth, over 14 years would mean that the emissions target is 16% below year 2014 BAU levels. However, this lower rate of population growth masks a growth in potential energy consumption. For example from Table 2 we see that the number of private dwellings has been increasing at 1.2% per year recently. This is consistent with the known contribution of decreasing household size (more residential space per person) to overall GHG emissions[12]. Additionally it may be noted that while Ontario's population growth was about 1.1% per year between the 2001 and 2006 census years, the total number of road vehicles registered grew by 1.6% per year[13].

[11] *Kingston Profile 2004 Demographics*, Kingston Economic Development Corporation. The mid-range population growth projection was about 0.8% per year.

[12] *Effects of household dynamics on resource consumption and biodiversity*, J. Liu, G.C. Daily, P.R. Ehrlich, & G. W. Luck, Nature **421**, p. 530, (2003).

[13] Statistics Canada, CANSIM Table 405-0004.

Table 2

Census Year	Population	Annual Growth Rate since last census	Total Private dwellings	Annual Growth Rate since last census
1996	112,605			
2001	114,195	0.28%	50,755	
2006	117,207	0.52%	53,838	1.19%

Souce: StatsCan

It would seem from this analysis that BAU emissions could possibly be expected to grow faster than population, increasing the difficulty of achieving the target.

Sources of Greenhouse Gas Emissions

Data from various places was gathered during the summer of 2007

Now we shall examine, in turn, each of the main sources of greenhouse gas emissions as identified in the year 2000 baseline study, and try to estimate how they have varied from 2000 to 2006.

Electricity[14]

Our electricity use has gone up around 4% from 2000 to 2006, but our related CO_2 emissions have decreased by about 24% because of the decreased use of coal and the increased use of nuclear power to generate our electricity

The calculation of GHG emissions attributable to the consumption of electricity depends on how much fossil fuel is used to generate that electrical power. The relevant quantity is the carbon intensity of electricity and has units of tonnes of CO_2 emitted per MWh. For example, a coal plant emits 0.9 tCO_2/MWh while a hydro plant emits about 0 tCO_2/MWh. These are emissions on the margin, so we are not counting the fixed amount of emissions involved in the construction of the hydro plant.

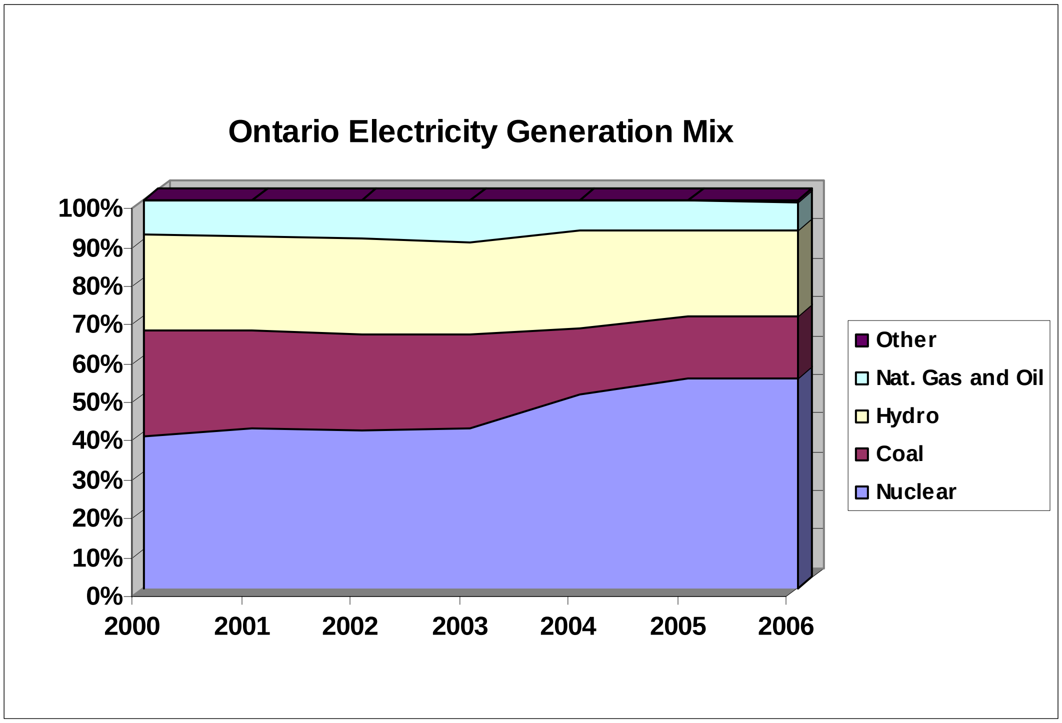
To calculate how this number has changed over the years we need to get two pieces of data. One is the Ontario electricity generation mix for each year. We will assume that the greenhouse gases emitted, in order to generate the electricity that Kingstonians pull from the grid, come from the mix of generation types as given by the Ontario Energy Board (2000-2003) and the Independent Electricity System Operators (2004-2006). The second piece of data is the carbon intensity from the fossil fuel power plants in Ontario. Here are a table and a graph showing Ontario's electricity generation mix. Note that renewable energy generation is not significant yet.

[14] The electricity data from Utilities Kingston includes electricity used to provide water for the City of Kingston, Ken Mundell, private communication.

Table 3
Ontario Electricity Generation Mix

YEAR	Nuclear	Coal	Hydro	Nat Gas + Oil	Other
2000	39.0%	27.3%	24.7%	9.0%	0.0%
2001	41.3%	25.3%	24.3%	9.1%	0.0%
2002	40.8%	24.6%	24.9%	9.7%	0.0%
2003	41.3%	23.9%	24.0%	10.8%	0.0%
2004	50.0%[15]	17.0%	25.0%	8.0%	0.0%
2005	54.0%	16.0%	22.0%	8.0%	0.0%
2006	54.1%	16.0%	22.3%	7.3%	0.3%

Figure 2



Data source: Ontario Energy Board and Independent Electricity System Operators

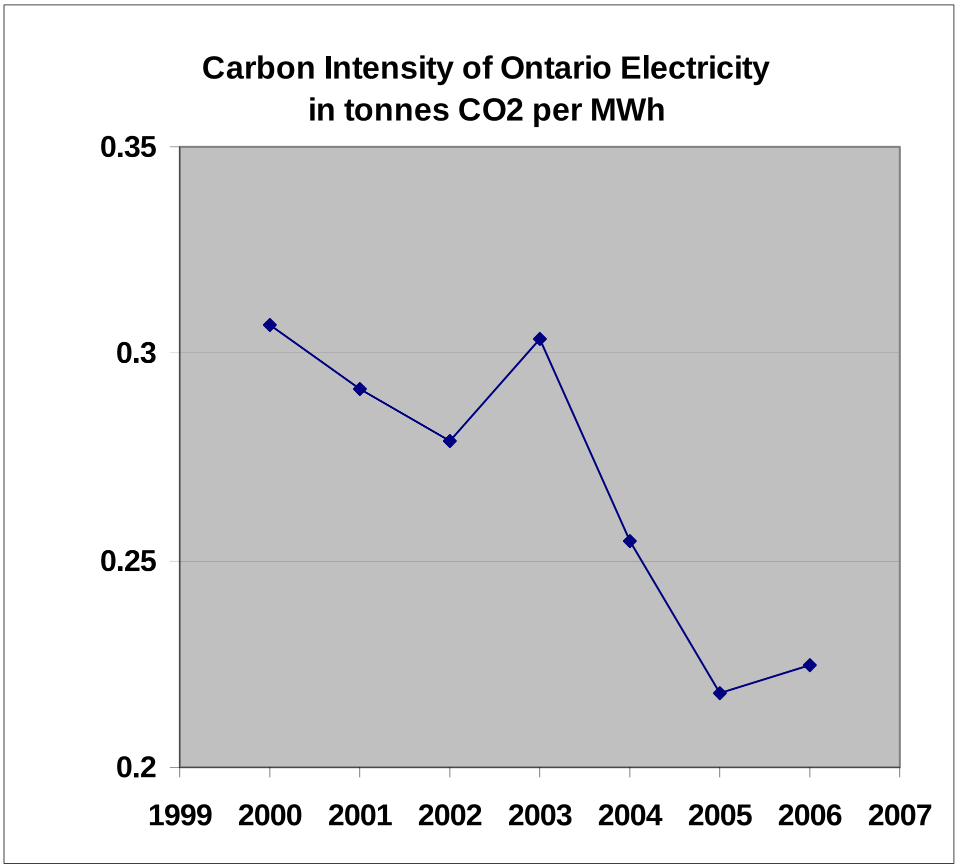
The carbon intensities for fossil fuel generation are available because all of the main facilities are owned by Ontario Power Generation (OPG). OPG publishes the annual amount of electrical energy generated and the corresponding GHG emissions from each of its fossil fuel generating facilities[16]. The data is reproduced in Appendix A.
Combining the generation mix and the carbon intensities for fossil fuel generation in a weighted average we can calculate the carbon intensity of electricity from the Ontario grid. The results are shown in Figure 3 and Table 4.

[15] At about this time the Pickering and Bruce A stations increased power generation
[16] Ontario Power Generation Sustainable Development 2006 Report and preceeding years.

Table 4

YEAR	Carbon Intensity (t CO_2/MWh)
2000	0.307
2001	0.292
2002	0.279
2003	0.304
2004	0.255
2005	0.218
2006	0.224

Figure 3



The compilation of electricity consumption is slightly complicated by the fact that there are two service providers in the City of Kingston. Utilities Kingston provides electricity to the central (pre-amalgamation) part of Kingston. Hydro One Networks provides electricity to the outer (old townships) part. There are two things that we would like to do with the raw data.

First of all, data was not available from Hydro One Networks for the years 2000-2002. We would like to use the observed dependence of electricity use on the number of customers, heating degree days[17] (HDD), and cooling degree days[18] (CDD) to make an educated and conservative extrapolation of electricity demand from 2003 back to 2000.

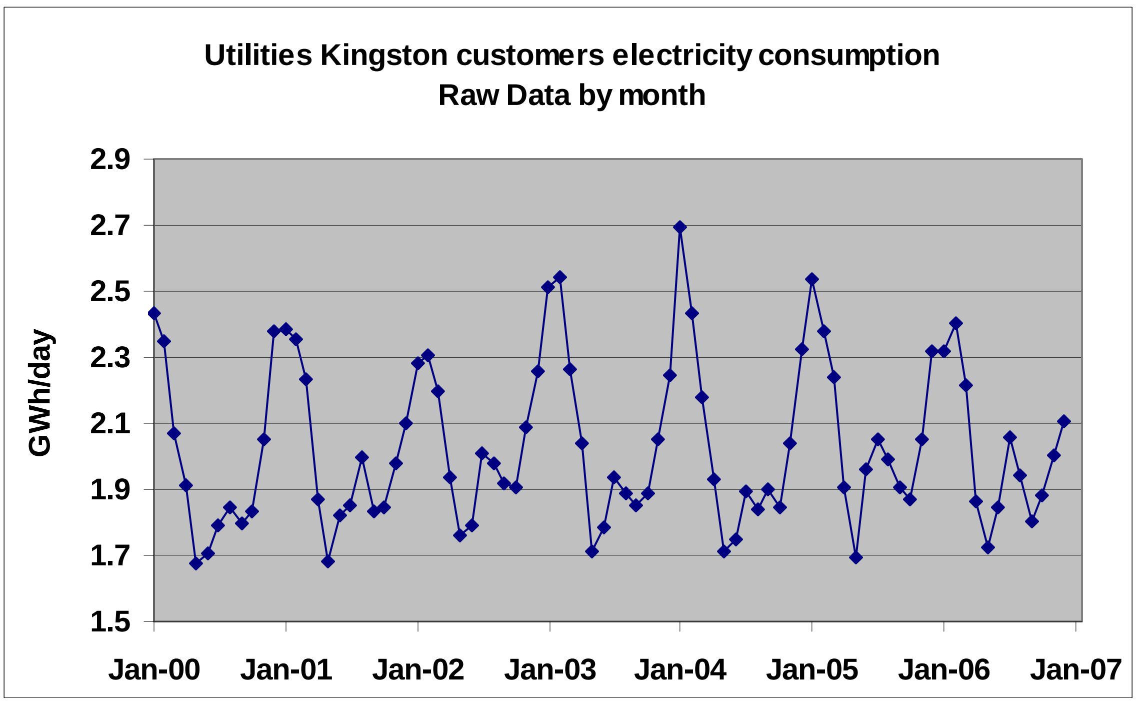
---

[17] Heating degree days are a measure of the need for heating. Roughly speaking, the number of degrees that a day's average temperature is below 18C is the number of heating degree days for that day.

Secondly, we would like to know how much the weather[19] (heating and cooling degree days) has really affected electricity consumption. We are constructing a Local Action Plan for GHG emissions reductions and we should allow for the possibility that the weather in the future may cause increased electricity use.

Electricity usage is highly seasonal (depending on the amount of light, expected seasonal heating and cooling, and activity tied to the school year) and weather dependent (each year's particular heating and cooling needs). Figure 4 shows the raw data for electricity consumption by Utilities Kingston customers and illustrates the seasonality. Monthly data for the entire period Jan. 2000 – Dec. 2006 was provided by Utilities Kingston.

Figure 4
Raw electricity consumption

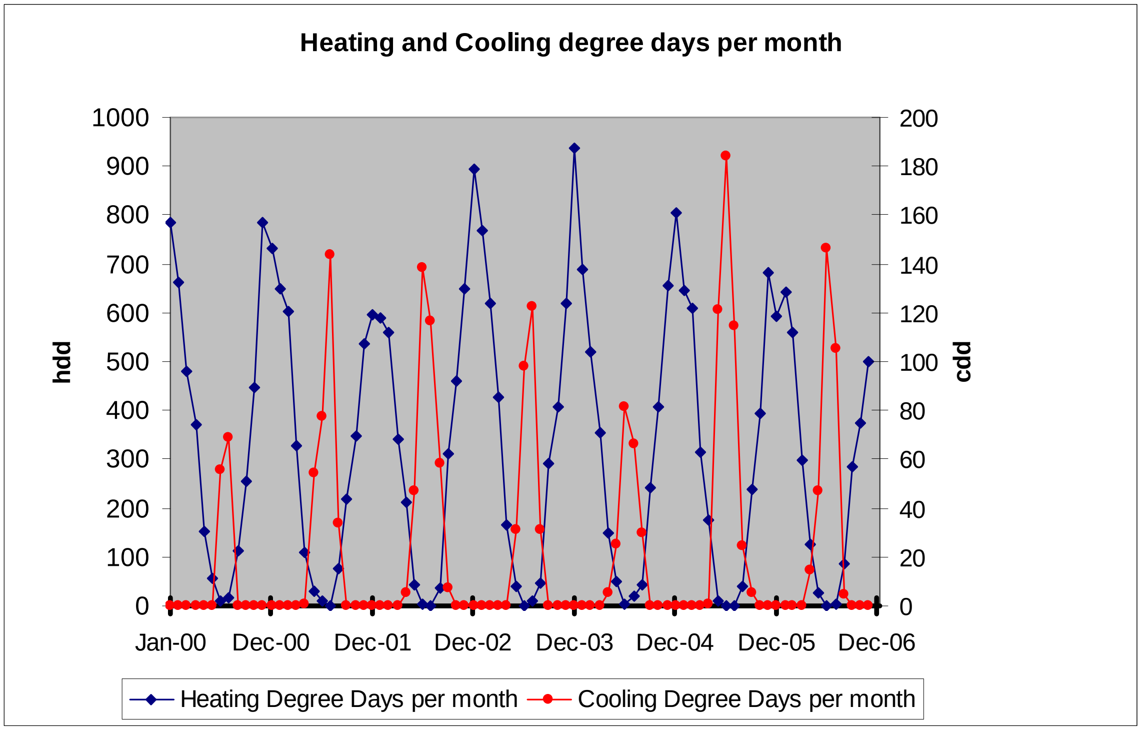


The weather has a large predictable component (winters cold, summers hot) and a smaller component that varies from year to year. Weather will also be important when we consider natural gas usage.

[18] Cooling degree days are a measure of the need for cooling. Roughly speaking, the number of degrees that a day's average temperature is above 18C is the number of cooling degree days for that day

[19] As far as weather goes we will only consider heating and cooling degree days in this paper. We do not have data on other things that affect electricity usage such as humidity (affects usage of air conditioning), cloud cover (can affect cooling requirements in the summer and lighting needs), and wind chill (can increase need for heating in the winter).

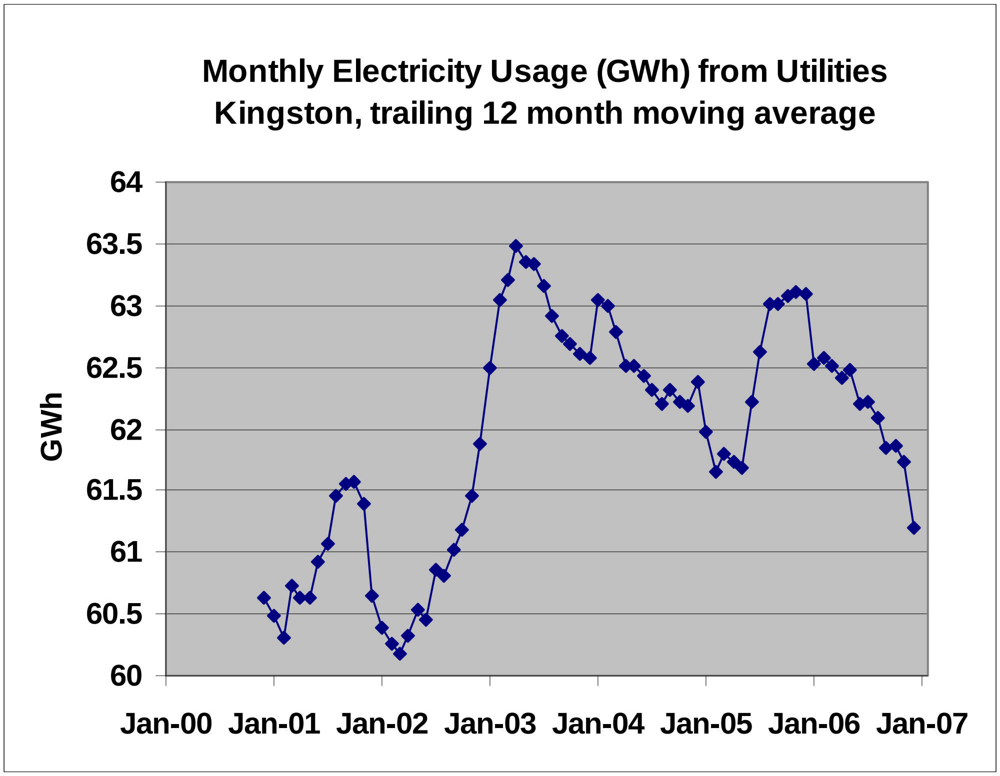
Figure 5



In order to tease out the weather dependence of electricity usage we examined a 12 month moving average[20] in order to remove seasonal variations like the number of daylight hours, the school year, and the average winter heating and summer cooling usage of electricity. A linear fit of this moving average to heating degree days, cooling degree days, and the total number of customers was attempted.

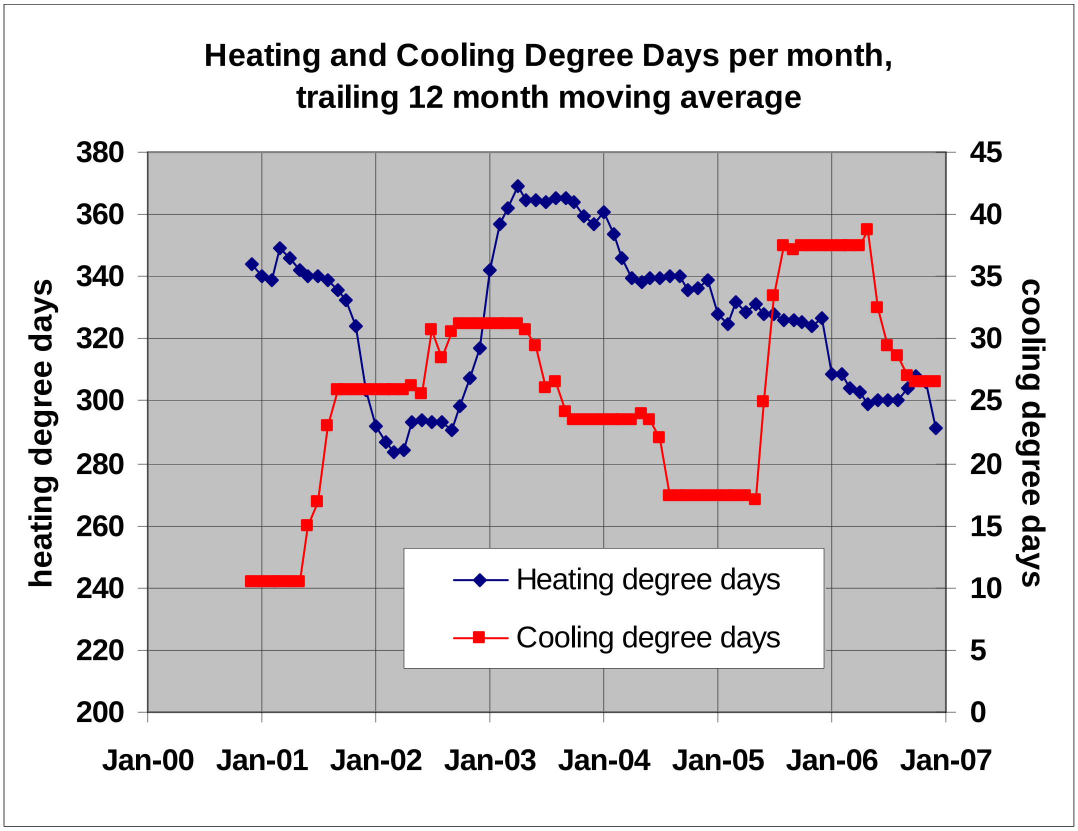
[20] The 12 month moving average means that for a point in Figure 6, April 2002 for example, the average of the last 12 months' (May 2001 to April 2002) electricity usage is plotted.

Figure 6



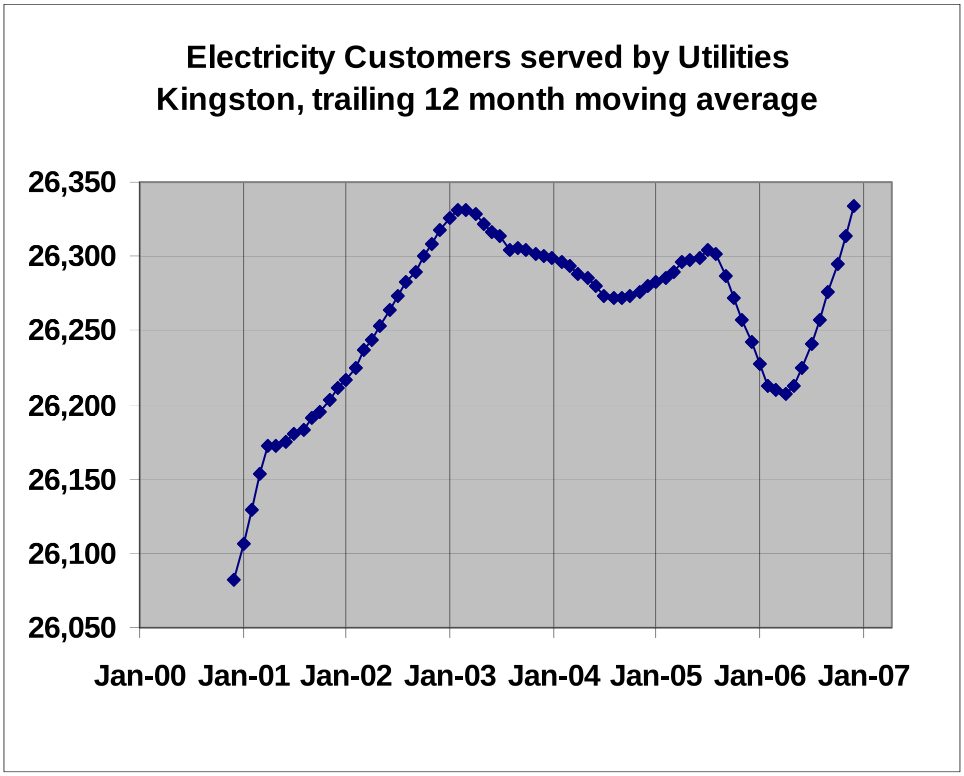
This trailing 12 month moving average electricity usage would have to be fitted to the trailing 12 month moving average heating and cooling degree days as shown in Figure 7.

Figure 7



The third factor used in the fit for electricity use was the number of customers

Figure 8



The result of fitting Utilities Kingston data resulted in the following:

- The CDD elasticity of electricity demand, that is, the fractional change in electricity demand divided by the fractional change in cooling degree days was 0.03.
- The HDD elasticity of electricity demand, that is, the fractional change in electricity demand divided by the fractional change in heating degree days was 0.15.
- The customer number elasticity of electricity demand, that is, the fractional change in electricity demand divided by the fractional change in customer number was 1.7.

Let us illustrate the meaning of a CDD elasticity value of 0.03. The average number of cooling degree days in one year was 295. The average amount of electricity used by Utilities Kingston customers in one year was 741 GWh. If July and August were about 1 degree warmer so that the number of CDD increased by 60, the extra energy used would be 0.03 x 741 GWh x 60 days / 295 days = 4.5 GWh. At a marginal cost of electricity of 10 cents per kWh, such a summer might cost Kingstonians $450,000 in electricity.

Hydro One Networks Data

Hydro One Networks data had to be extrapolated backwards from 2003 to 2000

From fitting residential usage data to HDD and CDD it seems that there is little correlation of electricity use with heating degree days in the Hydro One Networks service area. However, a real correlation could have been masked by a steady increase in the number of customers at the same time (2004-2006) that winters were steadily warming (and winter heating needs decreasing) (See Table 5). Unfortunately, customer number data was available only from 2004 to 2006 and only on an annual basis. The number of Hydro One residential customers seems to be growing at about 1.6% per year from 2004 to 2006. Using the customer number elasticity of demand from the Utilities Kingston fit would imply an annual *increase* of 2.7% in electricity demand. One the other hand, the number of heating degree days *decreased* about 14% from 2004 to 2006. Using the HDD elasticity of demand gotten from the fit to Utilities Kingston data, one would have expected this to have produced a decrease of about 2.1% in Hydro One residential electricity usage. Without good data on the growth in the number of customers it is hard to estimate the effect of heating degree days on electricity usage from the Hydro One data alone.

As for the dependence of consumption on summer temperatures, the fitted fractional increase in residential electricity use is about 0.02 times the fractional increase in cooling degree days. This is not far from the number 0.03 found from the Utilities Kingston data. This fit was possible because whereas the number of HDD went straight down with time (making its effect easily confused with the effect of the number of customers going straight up) the variation in CDD was not monotonic. It was not possible to do a CDD fit for non-residential Hydro One data because of a large industrial/commercial shutdown in the second half of 2004 which reduced electricity use in that sector by about half.

Extrapolating back to 2000

To extrapolate Hydro One customer consumption back to the year 2000 we will do a conservative estimate, in an attempt to not underestimate the growth in electricity usage since the year 2000. We'll be using the following inputs:

Table 5

Year	Hydro One residential customers	HDD	CDD
2000	*unavailable*	4131	125
2001	*unavailable*	3640	310
2002	*unavailable*	3806	373
2003	*unavailable*	4285	282
2004	16927	4068	208
2005	17087	3919	450
2006	17473	3494	318

Let us suppose that the 2.7% annual growth of residential electricity demand continues to apply to residential and non-residential electricity demand as we go back to the year 2000. This assumes that there were no startups or closures of large industrial or commercial users of electricity during this period. The estimated decrease in demand from customer growth as we extrapolate backwards from 2003 to 2000 is then 8.1%. The number of heating degree days decreases by about 3.5% as we go from 2003 to 2000. Extrapolating backwards would result in a 0.5% reduction in electricity demand, using the HDD elasticity derived from UK data.

The number of CDD decreases by about 50% as we go from 2003 to 2000. This implies a reduction of electricity use by 1.5%, using the more reliable Utilities Kingston CDD elasticity fit. Putting everything together, overall electricity use may have decreased by about 10.1% or about 3.4% per year extrapolating backwards to the year 2000. This is the way we filled in the missing Hydro One data in Table 6. It assumes that there was no change in large industrial/commercial customers during the period 2000-2002. That is the biggest uncertainty.

Table 6

Kingston Annual Electricity Consumption

Year	Utilities Kingston (GWh)	Hydro One Networks (GWh)	Total (GWh)
2000 baseline result			1370
2000	728	542*	1270
2001	728	561*	1289
2002	743	581*	1324
2003	751	601	1352
2004	749	567	1316
2005	757	601	1358
2006	734	590	1324

*extrapolated estimate

As a check that our estimate is conservative we may note that the year 2000 implied total electricity consumption from Hydro One + Utilities Kingston is less than the amount claimed in the 2000 baseline study (when actual data from Hydro One was available but the breakdown by company and the methodology are no longer available). As a result we are less likely to be overestimating growth and underestimating how much we need to cut our emissions in order to achieve the City Council target.

Finally we may combine our estimates of electricity consumption and the carbon intensity of grid electricity to produce an estimate of the time variation of GHG emissions from Kingston's electricity consumption.

Table 7

Year	Electricity Usage (GWh)	Emission Factor (t CO2/MWh)	GHG emissions (kt CO2)
2000 baseline	1370	0.313	430
2000	1270	0.307	390
2001	1289	0.291	376
2002	1324	0.279	369
2003	1352	0.304	411
2004	1316	0.255	335
2005	1358	0.218	296
2006	1324	0.224	297

The year 2000 electricity usage that we found using the present methodology is about 10% below the baseline value. However, it should be noted that the present methodology gives a lower starting point, thereby reducing the chance that it underestimates the growth in usage. Secondly, the goal of the present methodology is to be consistent over time, so a small disagreement in the absolute value of the GHG emissions is acceptable as long as we have some confidence in the time variation of the emissions.

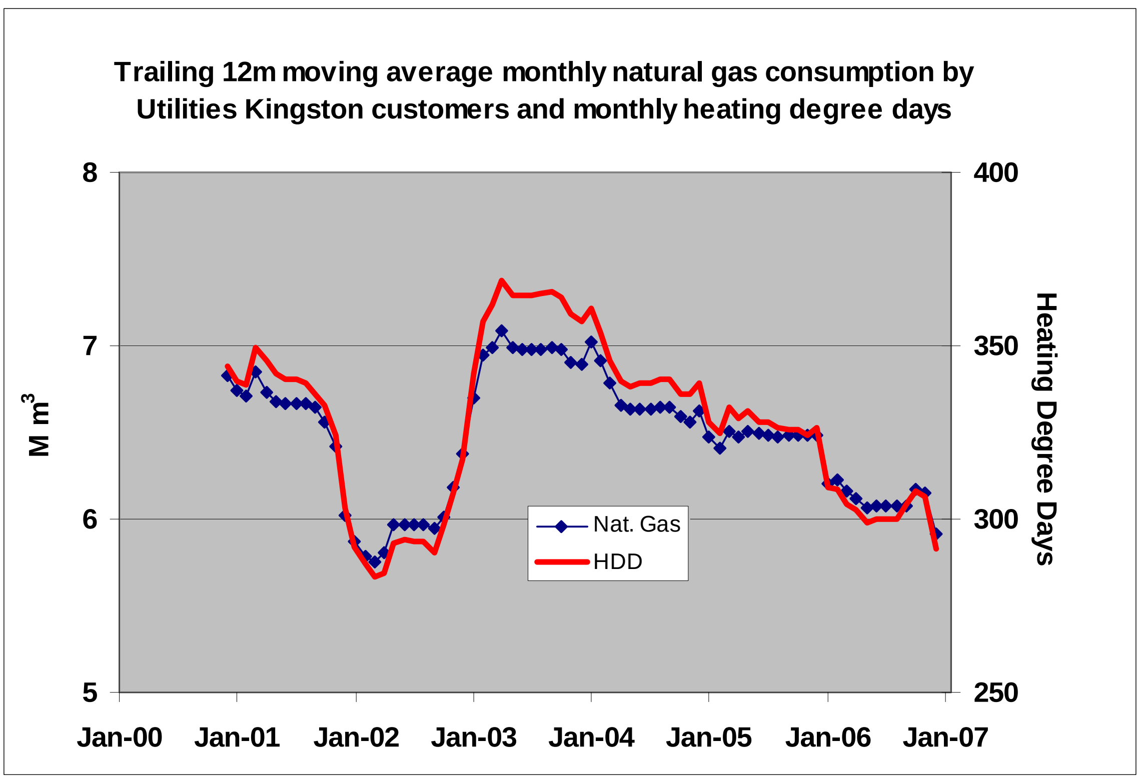
Natural Gas

GHG emissions from natural gas usage have gone down by about 8% because recent winters have been warmer.

Natural Gas supply in Kingston is broken up very much like electricity with Utilities Kingston serving the pre-amalgamation City and Union Gas serving the old townships. Just as for electricity we would like to know how much consumption might change depending on the weather (on heating degree days in this case) and we need to extrapolate Union Gas consumption data from 2003 back to 2000 in order to fill in unavailable data.

Again we will consider 12 month moving averages of monthly natural gas consumption data from Utilities Kingston in order to cancel out seasonal effects. It turns out that variations in residential use of natural gas are extremely well correlated with heating degree days.

Figure 9



Fitting Natural Gas consumption to heating degree days results in an HDD elasticity of natural gas demand, that is, the fractional change in natural gas demand divided by the fractional change in heating degree days, of 0.76.

In order to extrapolate the Union Gas data back to year 2000 (filling in the years 2000-2002) we made the following assumptions:

1. For small customers of Union Gas, the year to year variation of their consumption from 2003-2006 is observed to follow roughly the Utilities Kingston variation (and the variation in heating degree days), except for a roughly 2.5% extra annual increase in consumption, consistent with the roughly 3% annual increase in the number of customers[21] and the fact that the outer areas of Kingston are where space is more available for population/household growth. So we shall extrapolate backwards to the year 2000 by using the year to year percentage change in Utilities Kingston consumption to approximate weather effects and taking out 3% every year for annual growth in population and/or household number. We choose to use the larger 3% figure because we do not want to underestimate the growth in GHG emissions over time.
2. For large customers of Union Gas, consumption decreases from 2003 to 2006, but it doesn't look like it's correlated to heating degree days (see Table 8). We shall simply assume that their consumption is constant from 2000-2003. In any case the number of heating degree days in the two years 2000 and 2003 is roughly comparable so that at least one may hope that heating degree days do not contribute a systematic error to the result for the year 2000. The main uncertainty comes from the assumption that a large customer did not start up or close operations during the years 2000-2002.

Table 8

YEAR	Utilities Kingston (Mm^3)	Annual Variation	Annual HDD	Annual Variation	Union Gas small customers (Mm^3)	Annual Variation	Union Gas large customers (Mm^3)
2000	82.0		4131		*50.8*		*67.5*
2001	72.3	-11.8%	3640	-11.9%	*46.2*	*-9.1%*	*67.5*
2002	76.5	5.7%	3806	4.6%	*50.3*	*8.9%*	*67.5*
2003	82.7	8.1%	4285	12.6%	56.0	*11.3%*	67.5
2004	79.5	-3.8%	4068	-5.0%	54.4	-2.8%	67.4
2005	77.8	-2.2%	3919	-3.7%	56.7	4.3%	60.3
2006	71.0	-8.8%	3494	-10.9%	52.5	-7.5%	60.9

Note: grey highlighted figures are extrapolations

The estimate of total natural gas consumed in Kingston and the corresponding GHG emissions are shown in Table 9. The same conversion factor used for the year 2000 baseline was used here (1.88 kt/Mm^3)[22].

[21] Some of this growth is contributed not by new homes but by conversions to natural gas.
[22] This number may be checked at, for example, National Inventory Report 1990-2004, Greenhouse Gas Sources and Sinks in Canada, Environment Canada, Table A13-1

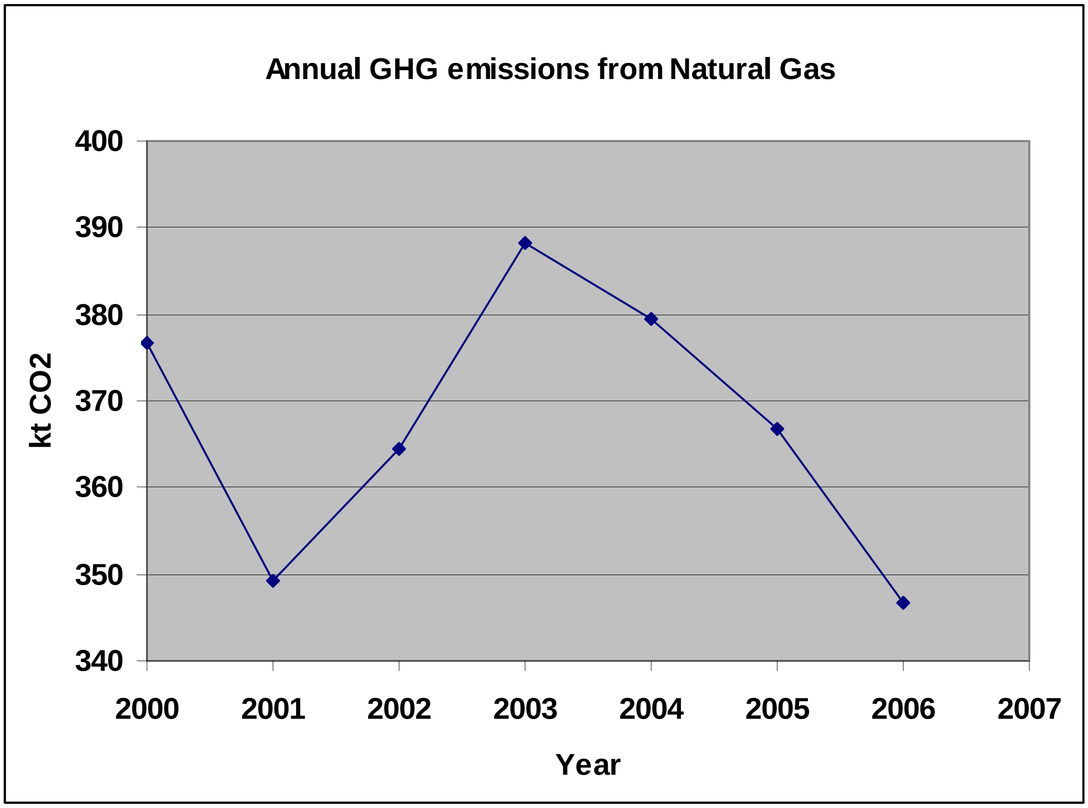
Table 9

Year	Nat Gas (Mm^3)	GHG emissions (kt CO_2)
2000 baseline	126	237
2000	200	377
2001	186	349
2002	194	364
2003	207	388
2004	202	379
2005	195	367
2006	184	347

There is a substantial difference in natural gas usage between the 2000 baseline study and the year 2000 value of this study. However, data from Union Gas was not available for the 2000 baseline study. Instead natural gas usage was estimated from electricity consumption by Hydro One customers and some assumptions about the relative consumption of electricity and natural gas[23]. That estimate may have missed the large "contract" customers.

[23] *City of Kingston: Community Emissions Inventory*, ICLEI Energy Services, September 11, 2003, Appendix B.

Figure 10



Natural Gas usage is down slightly from year 2000 to 2006 because of warmer winters[24].

Motor Fuel

Motor fuel use only went up by about 4% from 2000 to 2006. It was flat in 2001, and went down in 2004 and 2005

The year 2000 baseline value of gasoline use was estimated using the City of Kingston's Transportation Model. Population, employment, the transport survey trip database, and information about the City's road network were used to estimate the total number of vehicle kilometers per day. Vehicle type and fuel consumption by vehicle type breakdowns from the Canadian Vehicle Survey were used to estimate the amount of gasoline and diesel thus consumed[23].
Unfortunately, this methodology would require a lot of work to update from year to year. For this study, it was decided to look more directly at sales of motor fuel. Quarterly data from 2000-2006 on retail sales of gasoline and diesel in the City of Kingston were purchased from Kent Marketing Services[25]. We believe that this company is reliable because they provide data to the retail motor fuel industry. They send workers out to survey each retail establishment. Retailers that do not participate are not allowed to

[24] The HDD column in Table 9 documents the warmer winters, especially in 2006.
[25] Kent Marketing Services Limited, 199 Queen's Avenue, London, ON, N6A 1J1

purchase the data. Kent claims that nearly all gasoline stations participate[26]. Natural Resources Canada also purchases data from this company. As a matter of record and for future reference, a map of the city provided by Kent Marketing with the locations of surveyed gas stations is reproduced in Appendix B.

Unfortunately their survey methods are not able to capture sales of (mostly) diesel at commercial fueling stations, or "cardlock" facilities. Consumption of diesel by commercial users are therefore not captured by this data. We will, instead, estimate diesel use by examining data from the Annual Canadian Vehicle Survey[27]. This survey contains a table in which gasoline and diesel purchases for vehicles are tabulated for vehicles of different weights and types.

Table 10
Annual Canadian Gasoline and Diesel Fuel Consumption in Ml

Year	Total Gasoline	Total Diesel	Diesel/Gas ratio	Tractor Trailer Diesel	Net Diesel	Net Diesel/Gas ratio
2000	30670	11757	0.383	7400	5467	0.178
2001	30793	10266	0.333	6462	4774	0.155
2002	32681	10262	0.314	6459	4772	0.146
2003	32572	9859	0.303	6206	4585	0.141
2004	30930	9405	0.304	5839	4442	0.144
2005	29457	10077	0.342	6336	4691	0.159
2006	31111	10075	0.324	6367	4664	0.150
average	31174	10243	0.329	6438	4771	**0.153**

The ratio of gasoline use to diesel use is pretty constant except for the year 2000 unfortunately, since that is our baseline year. We are going to follow a recommendation by ICLEI[28] to subtract out 85% of the tractor-trailer diesel consumption, the estimated contribution of inter-urban highway trips[29]. The result is labeled "Net Diesel" in Table 10. The final result is an average ratio of diesel to gasoline use of 0.15. From the table it seems safe to assume that this ratio is constant in time (treating the year 2000 as an aberration). The data from the Canadian Vehicle Survey is not accurate enough to reliably discern any more detailed time dependence (It is a survey with large error bars on some data and is not a complete count).

Figure 11 shows raw quarterly data for average daily gasoline sales as well as a trailing 12-month moving average.

---

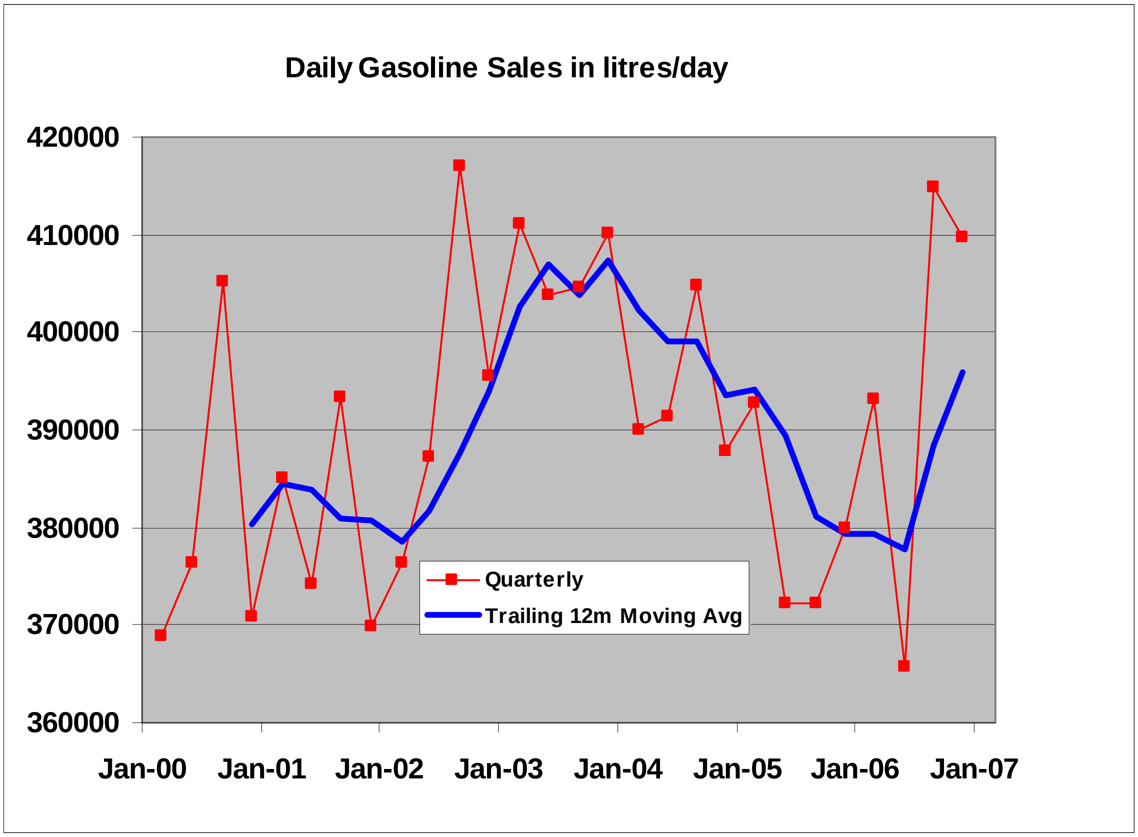
[26] From examining the figure in Appendix B, the author has only noticed one missing gas station, a small independent station called Petro Star Gas & Stop near Portsmouth Village.

[27] Statistics Canada, Canadian Vehicle Survey: Annual, 2000-2006, Fuel consumed by vehicle type, fuel type

[28] Letter from Al Seskus, ICLEI Energy Services to Beth Sills, City of Kingston, June 10, 2003, Re: Vehicular Greenhouse Gas Emission Estimates

[29] This recommendation was not used in the baseline estimate's methodology. However, it seems reasonable since highway tractor-trailer traffic is not directly under Kingstonians' control. Also, under the Kyoto protocol, international travel and shipping emissions are not counted in the GHG inventory of individual countries.

Figure 11



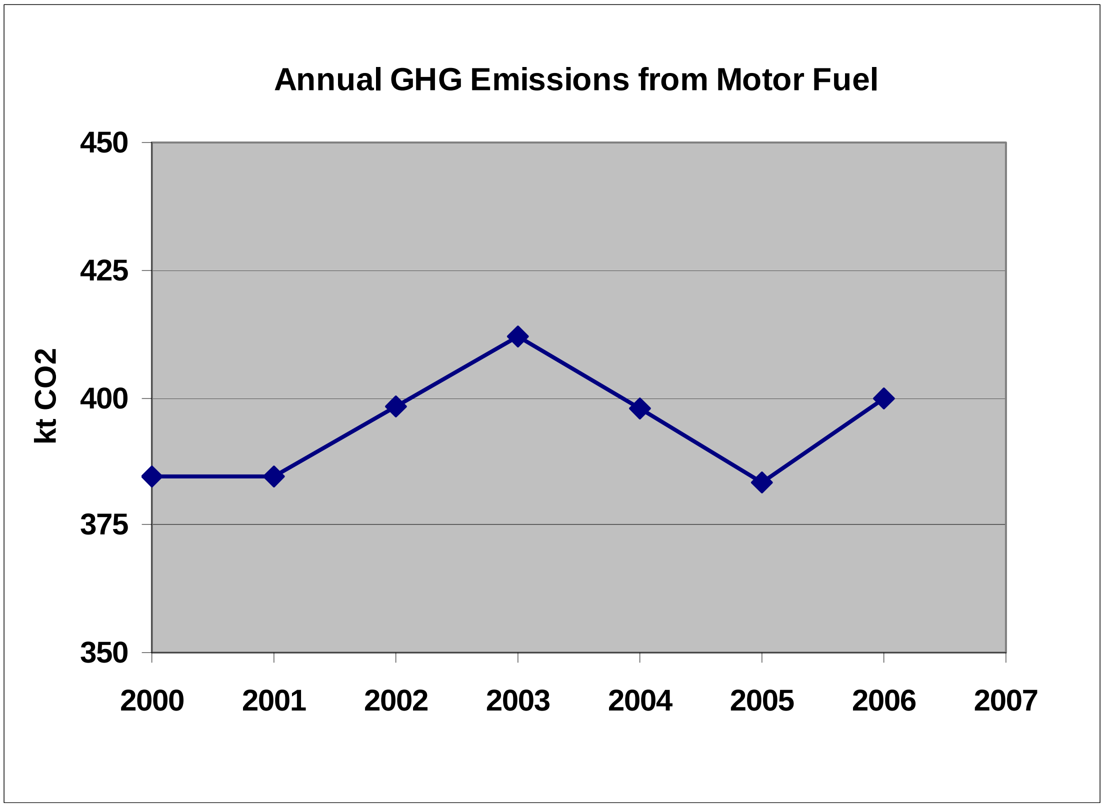
Motor fuel usage increased by only about 4% over the six years 2000-2006 and was even nearly unchanged from 2000 levels in early 2006. Gasoline and Diesel usage may be converted to CO_2 using the factors 2.36 kt/Ml and 2.73 kt/Ml for gasoline and diesel respectively[30].

Table 11
Kingston's annual consumption of motor fuel and resulting GHG emissions

Year	Gasoline (Ml)	Diesel (Ml)	Gas (kt CO_2)	Diesel (kt CO_2)	Total (kt CO_2)
2000 baseline	181	71	427	194	621
2000	139	20.8	328	57	385
2001	139	20.8	328	57	385
2002	144	21.6	339	59	398
2003	149	22.3	351	61	412
2004	144	21.6	339	59	398
2005	138	20.8	327	57	383
2006	144	21.7	341	59	400

[30] *National Inventory Report, 1990-2004 - Greenhouse Gas Sources and Sinks in Canada*, Annex 13 Table A13.1.4.1, Environment Canada.

Figure 12



Propane

Propane use is a small contribution to GHG emissions. It increased about 2% from 2000 to 2006.

Propane use in Kingston probably increased by a small amount from 2000 to 2006: around 2%[31]. Since Propane use contributes only between 2% and 3% of Kingston's total greenhouse gas emissions, this level of accuracy suffices. We will start with the year 2000 baseline propane usage, and then assume a straight-line increase of 2%, spread over six years. The greenhouse gas emissions factor is 1.53 kg CO_2 per litre of propane burned[32].

[31] Steve Barber, Territory Manager for Superior Propane, private communication.

[32] National Inventory Report 1990-2004 – Greenhouse Gas Sources and Sinks in Canada, Table A13-1, includes a contribution from N_2O emissions converted to an equivalent amount of CO_2

Table 12
Propane Consumption and GHG emissions

Year	Consumption (Ml)	GHG emissions (kt CO_2)
2000 baseline	20.1	30.7
2000	20.1	30.7
2001	20.2	30.8
2002	20.2	30.9
2003	20.3	31.0
2004	20.4	31.1
2005	20.4	31.2
2006	20.5	31.3

Heating Oil

Heating oil use is also a relatively smaller contributor to GHG emission. It probably decreased 12-16% from year 2000 to the present, following the weather

Heating Oil use has probably decreased by 12-16% or so from year 2000 to the present[33]. We could reproduce this result if we made the simple assumption that there were a constant number of customers following the consumption pattern of Utilities Kingston natural gas customers. Both would be expected to follow the over-all variation in the number of heating degree days from 2000 to 2006. We start with the baseline consumption in year 2000 and then assume that heating oil use also followed natural gas usage as determined by the number of heating degree days. In any case, heating oil contributes only about 3% of Kingston's total greenhouse gas emissions, so this level of accuracy suffices. The conversion factor is 2.83 kg CO_2 per litre of oil burned[34].

Table 13
Heating Oil Consumption and GHG emission

Year	Consumption (Ml)	GHG emissions (kt CO_2)
2000 baseline	13.8	39.0
2000	13.8	39.0
2001	12.1	34.2
2002	12.8	36.1
2003	14.0	39.5
2004	13.5	38.0
2005	13.1	37.1
2006	12.0	33.8

Waste in landfills

Waste in landfills does not presently contribute significantly to our GHG emissions because the methane emissions are burned off or used to generate electricity

33 Adam Koven, Rosen Fuels, Kingston, ON, private communication.
34 National Inventory Report 1990-2004 – Greenhouse Gas Sources and Sinks in Canada, Table A13-2.

Greenhouse gases can be emitted by organic solid waste deposited into landfills. There, as it decays anaerobically over time, it releases methane gas. Methane gas is a strong greenhouse gas having a "global warming potential" of about 20 times that of an equal weight of CO_2. However, methane gas can be collected and burned (simply flared or even used to generate electricity), converting it to water and CO_2[35] and reducing its global warming potential.

It is possible, as was done in the 2000 baseline study, to estimate the greenhouse gases emitted from household solid waste over the entire time it lies decaying in the landfill. However, as we shall see, that calculation is, for the moment, unnecessary.

In the 2000 baseline inventory it was assumed that there was no flaring of methane from landfills. However, in 2000 most of our waste went to the Richmond landfill near Napanee[36]. Almost all of the methane there has been flared starting in about 2000 and continues to be so[37]. So at the Richmond landfill there will be minimal GHG emissions over the lifecycle of waste deposited there in 2000 and thereafter.

Currently Waste Management takes our solid waste to various landfills in upstate New York. The methane from all of these landfills is flared or used to generate electricity.[37]

It is worth mentioning for future reference that for our purposes, there is a slight risk that the landfills that accept our solid waste may use their methane flaring for selling carbon offsets in the future. At some small, old landfills it is often marginally uneconomical to collect the methane and there is no regulation requiring it. Some of these landfills are then fitted with methane collection and flaring equipment using funds coming from a counterparty looking to offset emissions elsewhere. Waste Management is a member of the Chicago Climate Exchange, a place where such offset contracts are registered. None of the upstate New York landfills nor the Richmond landfill are being used for trading in carbon offsets[37]. If any landfill methane flaring or power generation is used for offsets in the future, we would be responsible again for the emissions from our waste in those landfills.

In the baseline study it was assumed that no landfill methane flaring was occurring and that our annual solid waste in the year 2000 would generate a lifetime amount of about 25 kt CO_2. Today, for the reasons above, it seems that we should be able to ***rule out any significant greenhouse gas emissions from our solid waste***. When this study is updated in the future, we will have to check that the methane is destroyed at the landfills our solid waste goes to, and that this methane burning is not being used in offset trading.

Data Summary

Overall, our emissions are presently about 9% below year 2000 levels

Figure 13 shows the main contributors to Kingston's GHG emissions: Electricity, Natural Gas and Motor Fuel

[35] Most of the resulting CO_2 may not count towards greenhouse gas emissions because it comes from organic material that was formed from atmospheric CO_2 in the first place.
[36] City of Kingston: Community Emissions Inventory, ICLEI Energy Services, Sept. 11, 2003
[37] Wes Muir, Corporate Communications, Waste Management, private communication.

Figure 13

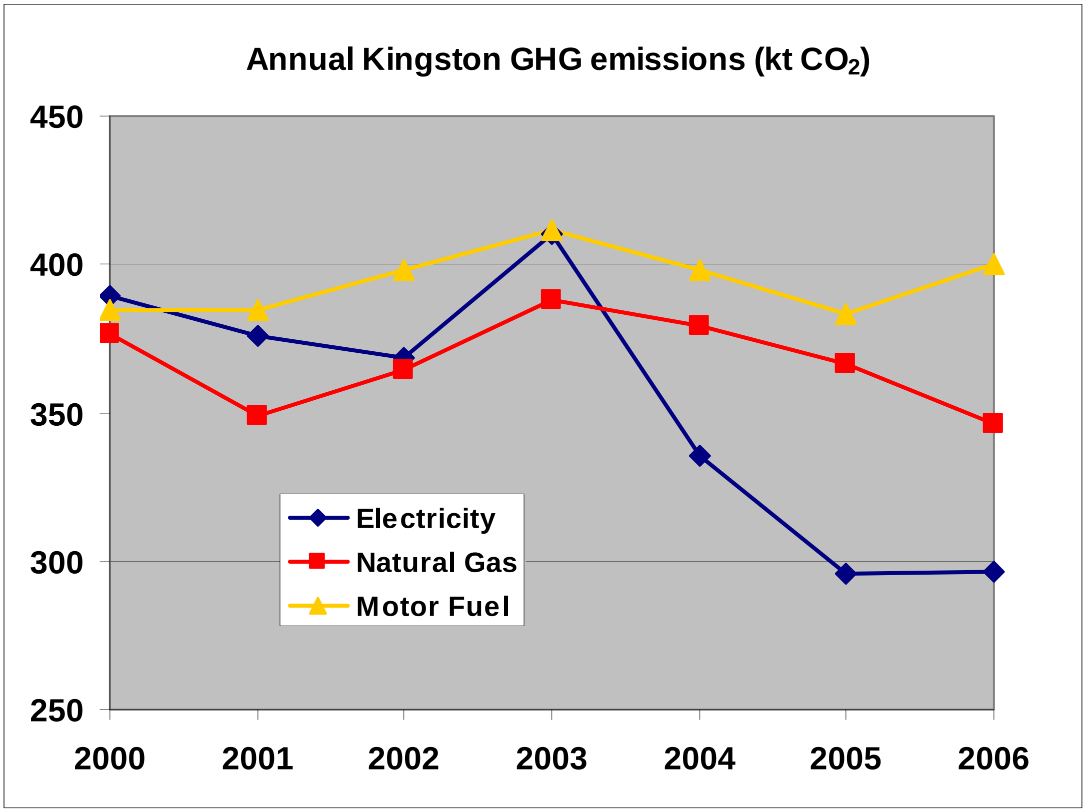
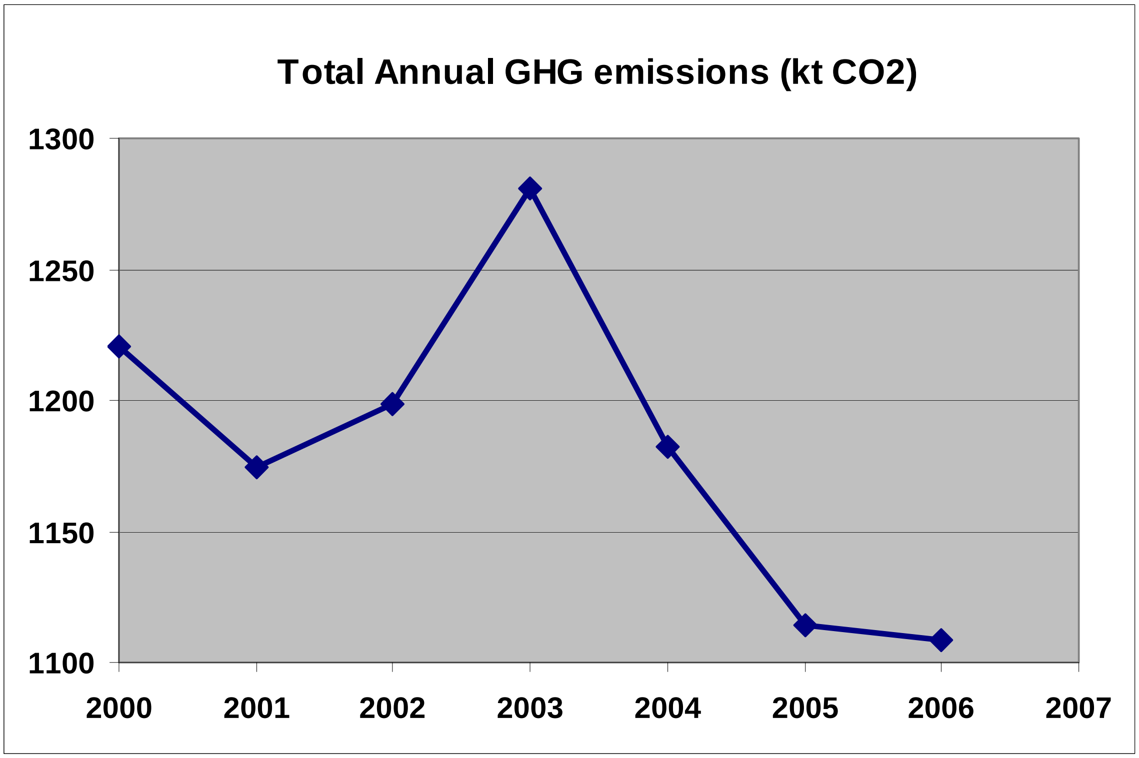


Table 14
Total Annual GHG Emissions

Year	Total GHG emissions (kt CO_2)	% change from year 2000
2000 baseline	1383	
2000	1221	
2001	1175	-3.8%
2002	1198	-1.8%
2003	1281	5.0%
2004	1182	-3.2%
2005	1114	-8.7%
2006	1108	-9.2%

Figure 14

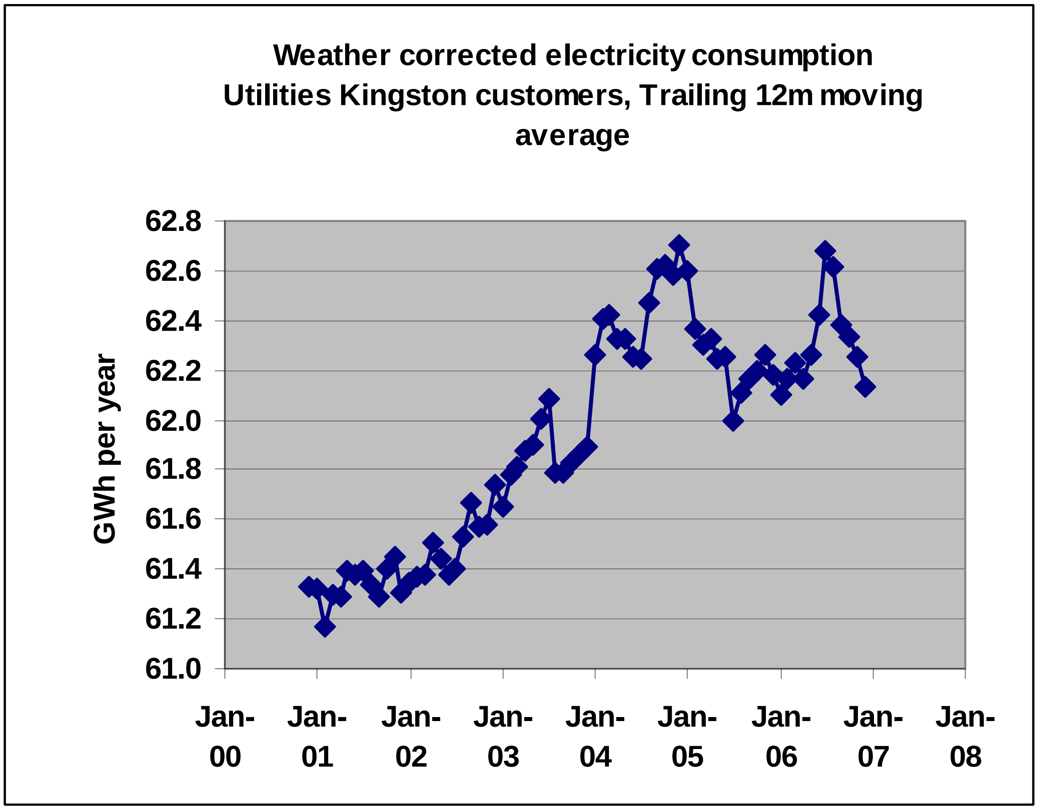


Discussion

The data may or may not show evidence of Kingstonians' efforts to conserve or use energy more efficiently. Most of the reduction in GHG emissions is from an increase in nuclear power, warmer winters, and perhaps higher motor fuel prices, all of which are not in our direct control.

The most important factor affecting Kingston's GHG emissions is the carbon intensity of our electricity. It has decreased substantially because of reduced coal power generation, and that has been possible because of an increase in generation by nuclear power at OPG's Pickering generating station and Bruce Power's Bruce A Units 3 and 4 starting around 2004.

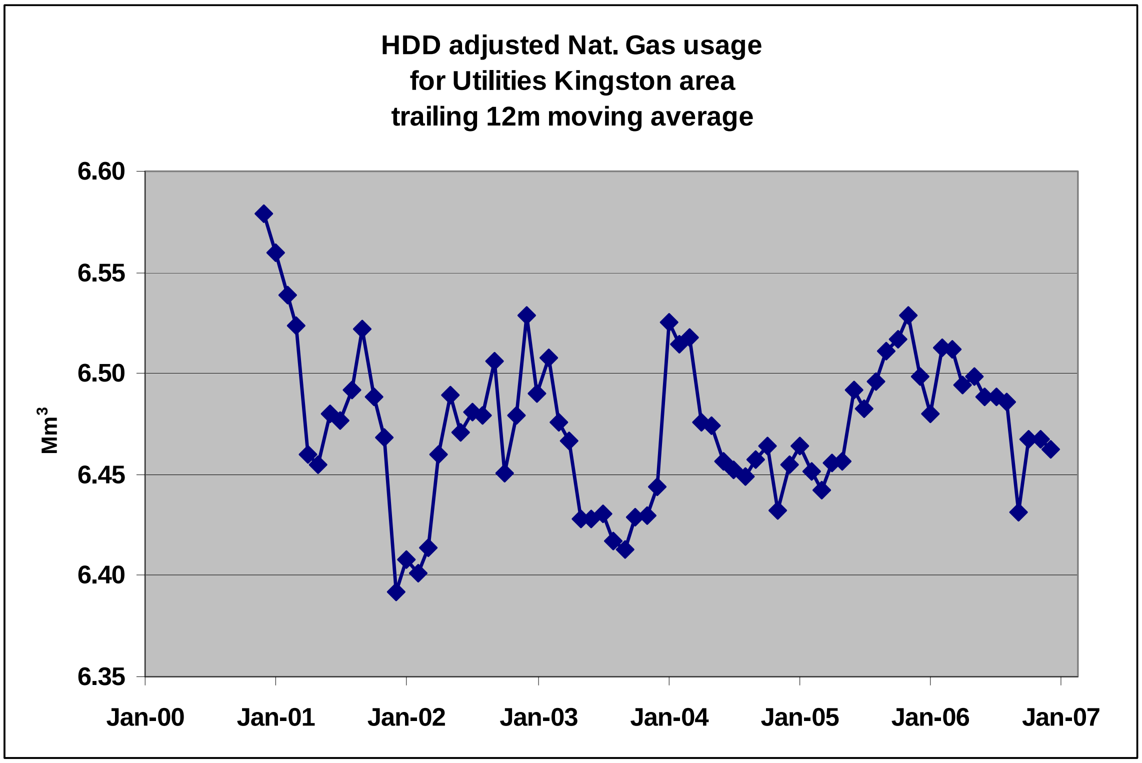
Figure 15



Let us consider local electricity consumption and see if there is any evidence for conservation[38]. Correcting electricity data for weather is a small effect. The adjusted Utilities Kingston consumption appears to increase by about 0.5% more than the unadjusted consumption. If we apply this extra 0.5% to the whole city of Kingston (applying it to the data in Table 6) the adjusted consumption increase from 2000 to 2006 would be about 4.8% (remember that we've tried to avoid underestimating growth in the former townships during the period 2000-2003). From this number it's hard to claim evidence for significant electrical energy conservation or efficiency gains by the inhabitants of Kingston because other things being equal we might expect very roughly a 0.5% annual increase in population (for a total of 3% over 6 years) or, alternatively, a roughly 1.2% annual increase in the number of households (for a total of 7% over 6 years).

[38] Utilities have had various Demand Side Management programs running and there may be some more direct observations of the efforts of Kingstonians to conserve energy.

Figure 16



Now we turn to whether or not there is evidence for conservation in the natural gas data[39]. Using the fitted elasticity of natural gas demand with respect to heating degree days, a set of weather adjusted natural gas usage data was created (Figure 16). The number of heating degree days was set to a constant equal to its average value from 2000 to 2006. This plot is interesting because, during this time period, adjusted consumption shows no average increase, while the number of natural gas customers increased by 13%! The likeliest explanation for this is that new customers of Utilities Kingston, living in the older, central part of Kingston, tended to live in high density abodes such apartment buildings[40]. Such customers would have less demand for heating. It should also be noted that the number of customers increased because of conversions from oil to natural gas. A change in home insurance policies made interior oil tanks less desirable[41]. If it were clearly the case that the population of the old City of Kingston (serviced by Utilities Kingston) grew (or that the number of households grew, which could also increase energy consumption), then one might be able to draw the encouraging conclusion that weather adjusted consumption had not grown commensurately. Unfortunately Statistics Canada no longer publishes the population residing within the pre-amalgamation city limits.

[39] Just as for electricity, the natural gas utilities have had Demand Side Management programs. It may be possible to get data on the participation rates in such programs.

[40] Stephen Sottile, Utilities Kingston, private communication.

[41] Nancy Taylor, Utilities Kingston, private communication.

Perhaps there *was* population or household growth in the old City because adjusted electricity usage by Utilities Kingston customers (Figure 15) does show growth commensurate with the known increase of about 1.0% in the actual number of electricity customers from 2000 to 2006. Most of the correlation is from the period 2000-2003 and in the last few years that correlation has been unclear (Compare Figure 8 with Figure 15).

Actual natural gas consumption growth has been checked because of warmer winters. This is a national trend and is not an artifact of having chosen 2000 as a baseline year. That is to say 2000 was not a relatively cold year.

Figure 17

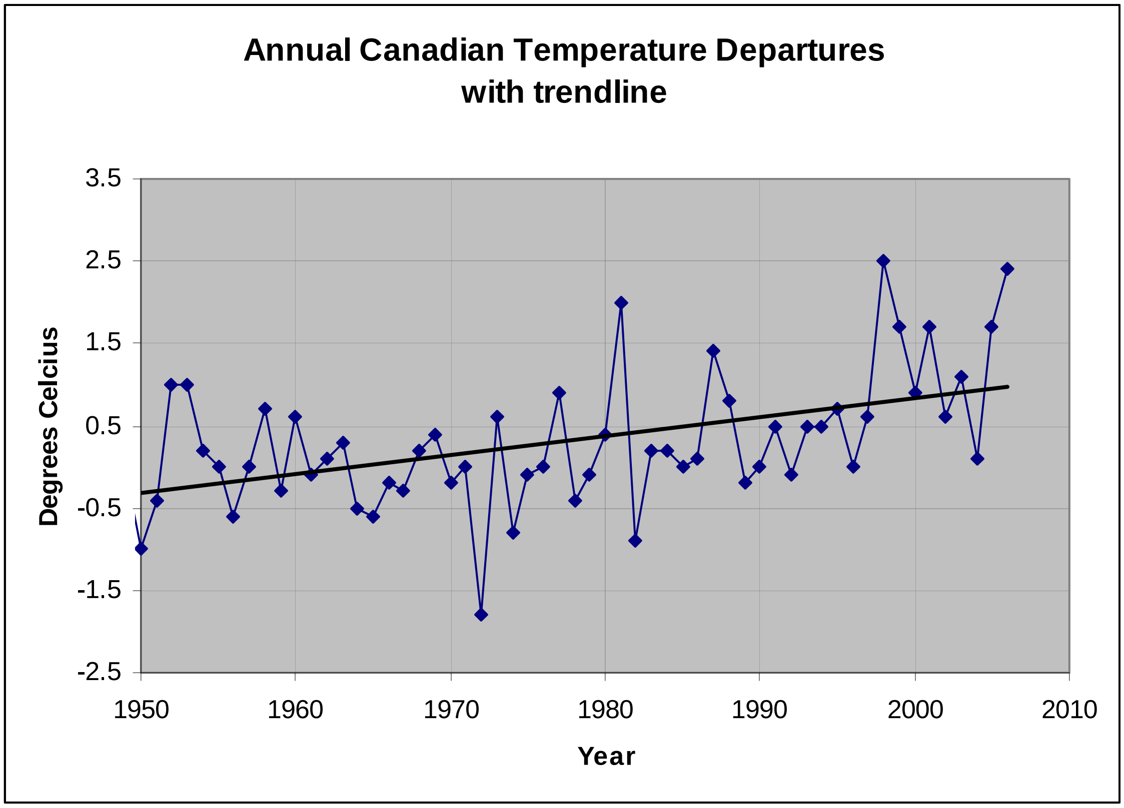
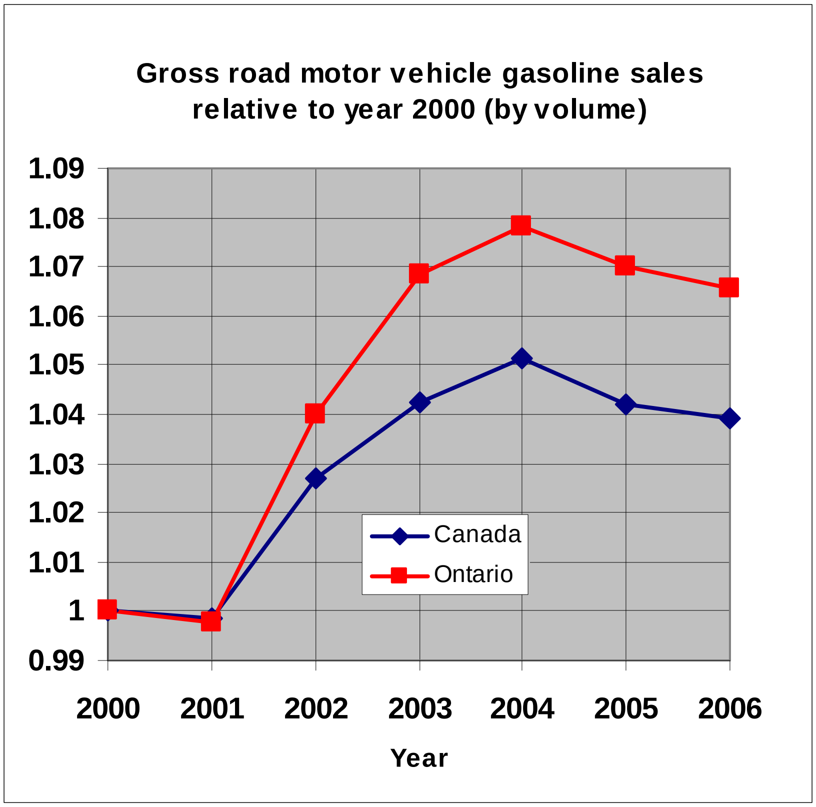


Figure 17 shows that the year 2000 was not a relatively cold year. It falls, fortuitously, right on the trend line. This is important to establish that the reduction in natural gas use from warmer winters is not an artifact from having chosen the year 2000 as a baseline year.

However, 2000 is somewhat special in that it is a year falling during a period after the late 1990's when some older nuclear reactors in Ontario had to be shut down and/or refurbished, and when ownership of these reactors was being restructured.

Now we turn to motor fuel usage in Kingston. The general trend of Kingston's retail gasoline sales shares some features of the provincial and national trends as shown in Figure 18, namely a small dip in 2001 and another decrease around 2005. It is interesting to note that gasoline use in early 2006 was almost unchanged from year 2000 levels until a spurt in late 2006. We can't prove that people tried to reduce gasoline usage but the decreases in certain years don't seem to be explained by over all economic conditions because Ontario road vehicle registrations, real GDP and diesel sales all showed steady growth.

Figure 18

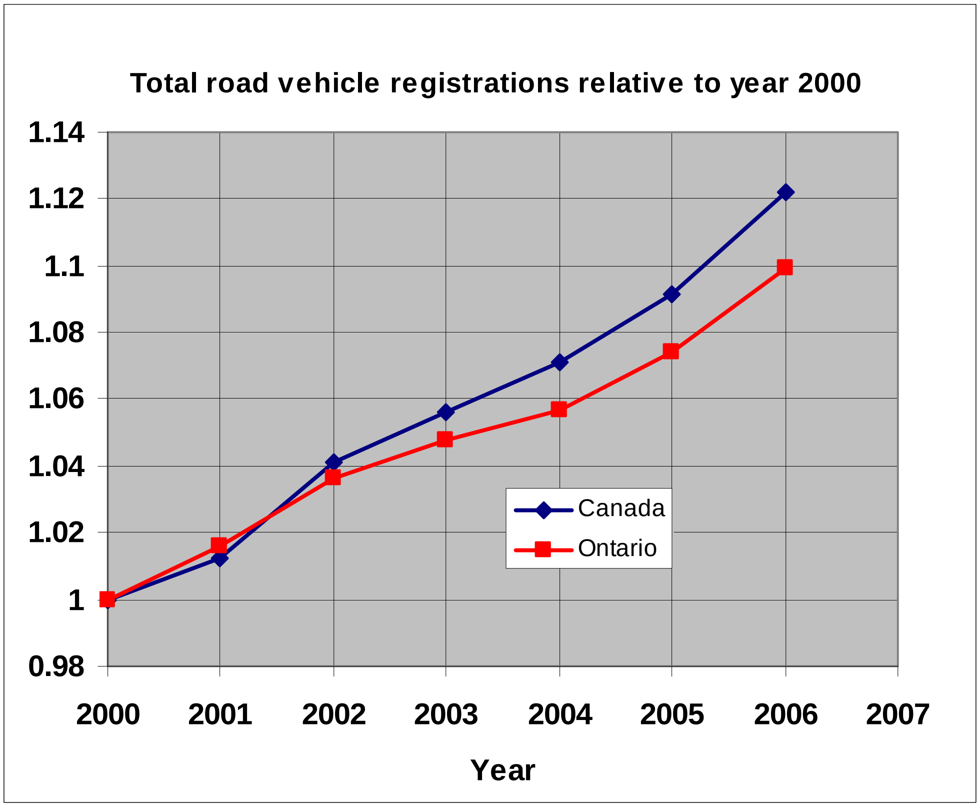


(source: StatsCan)

Consider the following statistics:

Total road vehicle registrations in Ontario increased steadily throughout this period (in step with an increase in Ontario's total population). Kingston's population and Kingston's number of households probably increased by about 3% and 6% respectively. So changes in population don't seem to explain Figure 11 and Figure 18.

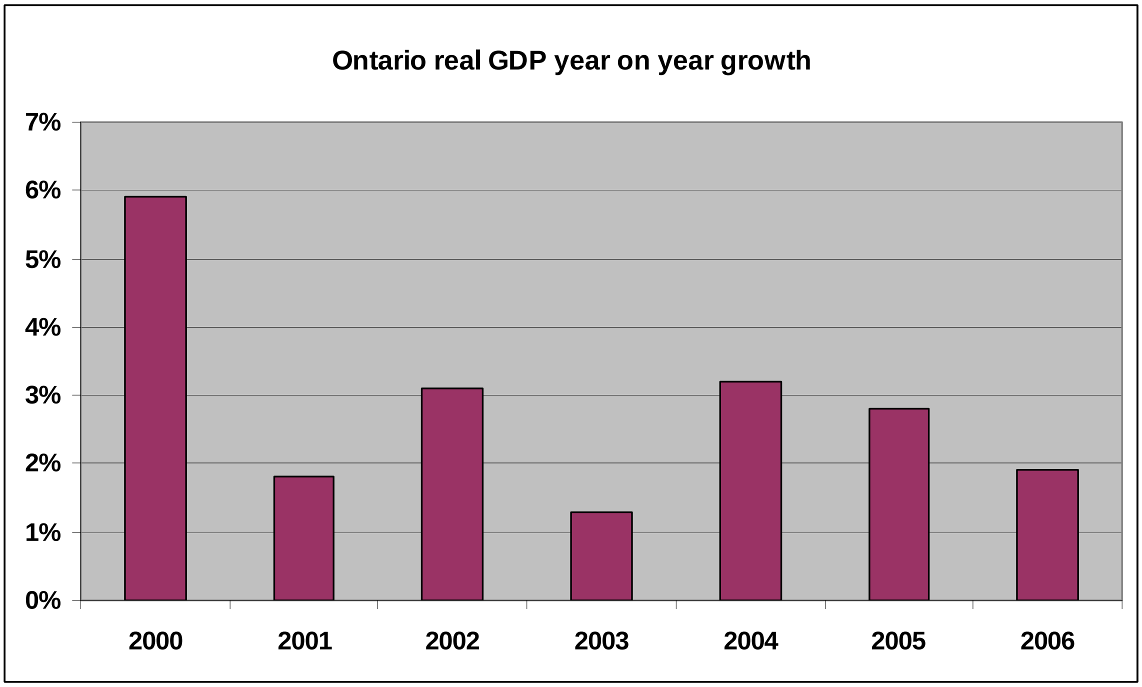
Figure 19
Total Road Vehicle Registrations



Source: StatsCan

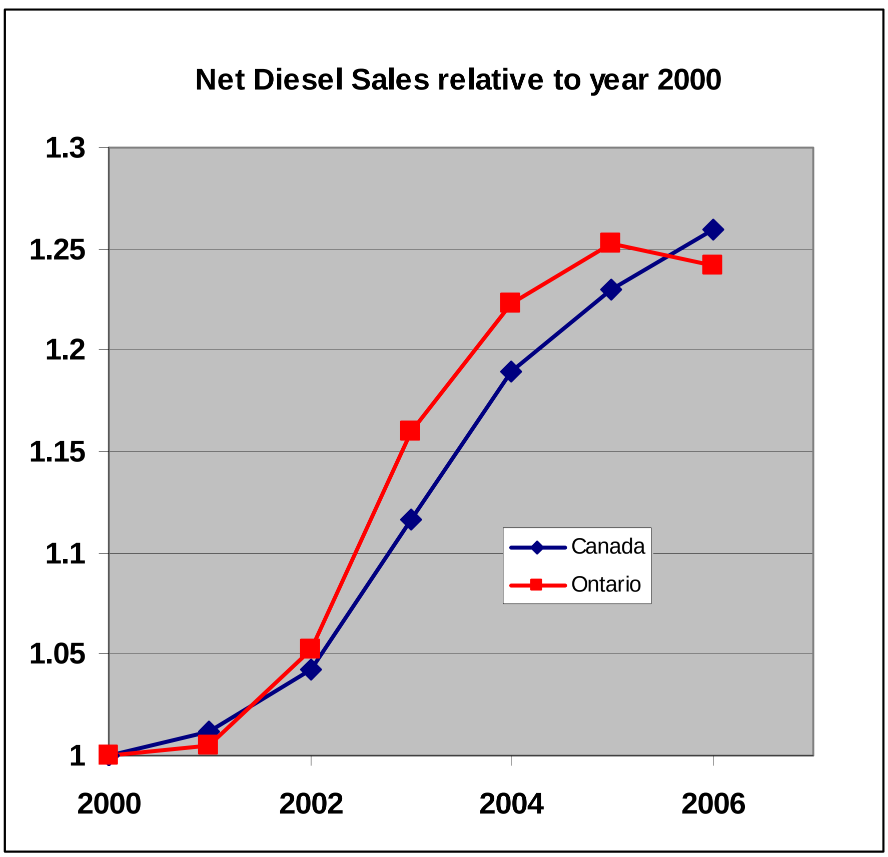
There has been positive year to year growth in Ontario's GDP as well as growth in diesel sales from 2000 to 2006 that doesn't correlate with the dips in gasoline consumed. This suggests but does not prove that something else is influencing gasoline consumption.

Figure 20



Source: Statscan

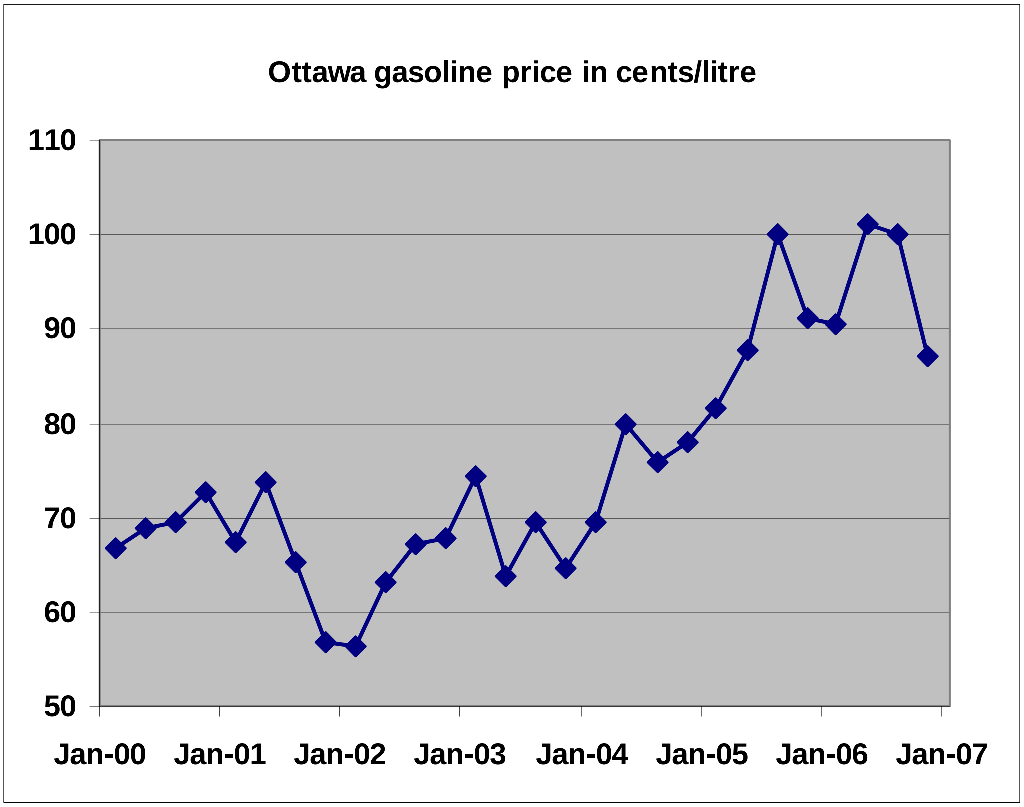
Figure 21



Source: Statscan

It is possible that consumption of gasoline in Kingston and elsewhere has been affected by the recent rise in prices. We do not have historical gasoline prices for Kingston, but Figure 22 gives an idea of what they might have been by plotting Ottawa gasoline prices

Figure 22



Source: Ontario Ministry of Energy

If Kingston drivers are indeed responding to increase motor fuel prices by choosing to drive less, or by purchasing more fuel efficient vehicles, then it might be reasonable to hope (for the purposes of constructing a local action plan) that a 5% decrease in consumption (based on the variability observed in our motor fuel data (Figure 11, Table 11) by 2014 is possible.

Expected growth from now until 2014

In order to meet our target, we should aim to reduce emissions by 16% below business as usual. This includes allowances for "normally" cold winters and the refurbishment of a nuclear reactor.

The years 2005 and 2006 were particularly warm years in Canada (see Figure 17). Let us consider how much Kingston's greenhouse gas emissions might be expected to increase if the number of heating degree days and cooling degree days returned to the year 2000 level. The values are listed in Table 5. Using the elasticity factors we derived from our fits we would guess that natural gas demand would increase by 14% and electricity demand would increase by 1% from year 2006 levels. Translating that to GHG emissions, we get about a 50 kt increase in CO_2 emissions or about 5% of our total.

The first unit of the Pickering B generating station is planned to be shut down for refurbishment some time during the years 2012-2017[42], around the time of our target year. If such a nuclear generator needed to be shut down, our electricity emissions factor might increase very roughly from 0.224 t CO_2/MWh to 0.25 t CO_2/MWh. That would increase our emissions from electricity by about 10% or 30 kt, about 3% of our total.

We are already around 9% below the year 2000 GHG emissions level. But if we want to reach our GHG emissions target, we should probably plan to overcome expected growth of about 1% per year (if not in population then in households and vehicles) plus a margin of error of about 8% in case the weather returns to trend line and a nuclear plant needs to be shut down. Thus we should be aiming for a reduction of about 16% below business as usual over the next seven years.

Additional sources of error

One significant source of GHG emissions is Portland cement. Kingston has a number of major construction projects at the moment[43]. That is certainly different from the situation in the year 2000 and will certainly change by the year 2014. We could not get an estimate of cement use in Kingston but the magnitude of the omission might be estimated from the fact that nationally in 2004 about 11.4 Mt of CO_2 emissions resulted from cement production[44] and Kingston's *per capita* share would be about 40 kt.

We encountered some difficulty in retrieving data all the way back to the year 2000. The monitoring required under the PCP program, that begins with this study, should be re-visited every couple of years because data isn't always stored accessibly for more than a few years. Waiting too long could make data retrieval will be more time consuming and more expensive, and may introduce significant uncertainties because of unavailable data.

Conclusion

It would be worth re-publicizing our target, along with an update on our GHG emissions, to attract the attention of the public and inspire more action.

Because of a significant reduction in our greenhouse gas emissions, albeit mostly from factors outside our direct control, the "10% below year 2000 emissions by the year 2014" target may in fact be not as difficult as we first expected. Without the intervention of those factors the emissions target may have been simply out of reach and not worth publicizing and pursuing. Instead, the data presented in this paper indicate that it is now

---

[42] http://www.opg.com/power/nuclear/pickering/pickB_overview.asp

[43] Such as the new police station, large venue entertainment centre, multiplex community centre, Queen's University expansion, and waterfront high-rises.

[44] National Inventory Report 1990-2004, Greenhouse Gas Sources and Sinks in Canada, Environment Canada, Section A10.3.5.

realistic to believe that the target is attainable (though still not without mounting a serious effort).

It is worth publicizing the target, pursuing it with a local action plan, and monitoring progress through continual updates to the results of this paper. Trying to achieve a realistically attainable target may provide some drama and attract the interest of the public. The public can and must make the difference in achieving the target and ‘real-time’ monitoring of this target may remind them and motivate them to act, and to show them what they have achieved.

So far in the data there are suggestions of but no clearly identified results from efforts by Kingstonians to reduce energy use. From now until 2014 it will be important that we are seen to be achieving this target *because* of our efforts and not in spite of our inaction. This goes back to the idea of fostering cooperation to solve a global problem that is of the “tragedy of the commons” type.

APPENDIX A
GHG emissions of Ontario fossil fuel power plants

Source: Ontario Power Generation Sustainable Development 2006 Report and preceeding years’ reports. The emissions of NOx contribute very little to the overall greenhouse gas emissions. Emissions of NOx are about 0.1% of the emissions of CO_2. Furthermore, according to the IPCC document, *Climate Change 2001*, *The Scientific Basis*, Section 6.12.3.4, the Global Warming Potential of NOx emitted at the earth’s surface is about 5. So including the effect of NOx would increase the CO_2 (eq) intensities in this table by only about 0.5%.

Plant	year	generation GWh	CO2 emissions kt	Intensity t/MWh
Atikokan	1999	1115	1130	1.013
	2000	994	1020	1.026
	2001	838	850	1.014

	2002	823	889	1.080
	2003	946	996	1.053
	2004	1018	1177	1.156
	2005	965	1104	1.144
	2006	737	849	1.152
Lakeview	1999	3271	3000	0.917
	2000	2905	2700	0.929
	2001	3081	2760	0.896
	2002	2450	2340	0.955
	2003	2806	2730	0.973
	2004	2297	2320	1.010
	2005	660	719	1.089
	2006	closed	closed	closed
Lambton	1999	9001	7800	0.867
	2000	12415	10800	0.870
	2001	10472	9420	0.900
	2002	10022	8990	0.897
	2003	10636	9500	0.893
	2004	7672	7170	0.935
	2005	9422	8650	0.918
	2006	6856	6451	0.941
Nanticoke	1999	19038	17000	0.893
	2000	23519	21500	0.914
	2001	21124	20260	0.959
	2002	22156	21370	0.965
	2003	20393	19740	0.968
	2004	14466	14672	1.014
	2005	17666	17580	0.995
	2006	16174	16223	1.003
Thunder Bay	1999	1643	1600	0.974
	2000	1613	1620	1.004
	2001	1670	1800	1.078
	2002	1490	1663	1.116
	2003	1474	1581	1.073
	2004	965	1119	1.160
	2005	962	1150	1.195
	2006	959	1128	1.176
All Coal	1999	30530	34068	0.896
	2000	37640	41446	0.908
	2001	35090	37185	0.944
	2002	35252	36941	0.954
	2003	34547	36255	0.953
	2004	26458	26418	1.002
	2005	29203	29675	0.984
	2006	24651	24726	0.997
Lennox Oil/gas	1999	2393	1600	0.669
	2000	1288	843	0.655
	2001	3243	1880	0.580
	2002	2762	1250	0.453
	2003	2775	1950	0.703
	2004	602	637	1.058
	2005	1263	954	0.755
	2006	317	282	0.890

Appendix B
Map of Kingston gasoline stations surveyed by Kent Marketing