2004 Wolfville Greenhouse Gas Emissions Report

Prepared by the Centre for Rural Sustainability and the Students of ENVS 1013: Introduction to Environmental Science

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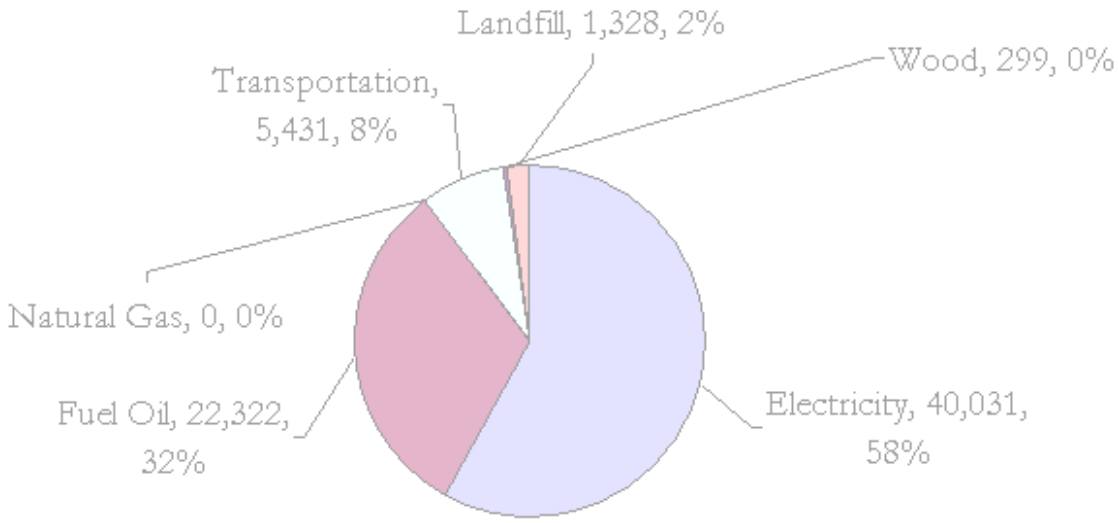

Submitted to Acadia University and Town of Wolfville, December 2004

Executive Summary

Climate change is becoming a pressing concern for Canadian society and the governments of Canadian municipalities. As a component of a project named the Wolfville Sustainability Initiative, the Centre for Rural Sustainability (CRS) worked to produce an early greenhouse gas emissions study of the community of Wolfville, Nova Scotia.

In November 2004, the CRS collaborated with Dr. Soren Bondrup-Nielsen of Acadia University, and the students in his Introduction to Environmental Science class, to complete this study. The objectives of this report were to:

- Quantify the amount of fossil fuels the community of Wolfville consumed in 2003, broken down by the following sectors of the community:
  - Residents
  - Businesses
  - Municipal Operations
  - Acadia University
- Quantify the amount of greenhouse gases produced by the community
- Calculate the number of dollars leaving the community to purchase these fossil fuel services
- Estimate the potential annual savings to the community at a 20% greenhouse gas emissions reduction
- Correlate these findings with additional indicators including:
  - Air quality in Wolfville (and financial costs) for 2003
  - Traffic counts in Wolfville in November 2004
  - Road congestion in Wolfville in November 2004

Major Findings:

- Wolfville's 2003 GHG output (conservatively calculated): 69,411 tonnes eCO2 ("equivalent CO2 units")
- This translates into approximately 8.5 tonnes of eCO2 produced per person in Wolfville.
- Wolfville's community exports $9,616,141 to purchase these fossil fuel services
- The two most significant sources of GHG emissions were:
  - Electrical use among community residents (18,387 tonnes) and at Acadia University (14,866 tonnes)
  - Fuel oil use at Acadia University: (13,474 tonnes)
- Potential benefits of a 20% community-wide energy use reduction:
  - 13,882 tonnes of eCO2 not emitted
  - $1,923,228 ($236 per capita) saved
  - Reductions in air pollution and traffic congestion

Major Recommendations:

- Make greenhouse gas emissions reductions a priority policy at Acadia University and Town of Wolfville, set emissions reduction targets, and implement actions to achieve them.
- Repeat this study in future years and improve on it.

The study was successfully completed, though data was often difficult to locate, and a number of assumptions and estimates were made. Despite the shortcomings of this report, and the potential inaccuracies within it, it is nevertheless a first attempt at quantifying and monitoring an important and timely issue.

Acknowledgements

The project team would like to acknowledge the contributions of several people who providing aid to this work. The creation of this report would not have been possible without the generous support and advice of the following people and organizations (in no particular order):

- Town of Wolfville: Marcia Elliott, Gladys Saltzman, Roy Brideau, Gregg Morrison, Brian Porter
- Acadia University
  - Building Services: Drew Peck
  - Physical Plant: Craig Quartermain
  - Environmental Science: Dr. Soren Bondrup-Nielsen, Joseph Mudge
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- Nova Scotia Power Inc.
- Nova Scotia Department of Energy: Jonah Bernstein
- Federation of Canadian Municipalities: Devin Causley
- Town of Perth, ON: Bob Argue
- Valley Waste Resource Management: Brian Van Rooyen

Introduction

Climate Change

Climate change is an alteration in the average weather that any given area or region experiences. A measurement of this typically includes changes in any of the things associated with weather such as temperature, wind patterns, and levels of precipitation. When we speak of climate change in terms of global warming, we are referring to the changes in the climate of the earth as a whole. The rate of climate change may differ for varying regions and the magnitude of long term effects on natural ecosystems can also differ.

The natural system known as the "greenhouse effect" allows the earth to maintain its temperature, but the continuous consumption and mechanization of world societies has resulted in an increase in the total concentration of greenhouse gases (GHGs) in our atmosphere. As these greenhouse gases increase, so does the earth's capacity to hold heat; and we are currently observing the most dramatic rate of change in atmospheric composition and temperature ever caused by humans.

Climate change impacts on any given region may vary from lower levels of precipitation in agricultural areas, thereby reducing productivity, to flooding in low lying areas due to rises in sea level. Increasing temperatures are predicted to melt glaciers, increasing the volume of water in the world's oceans by an estimated average of 5 to 10 cm per decade over the next 100 years. The interiors of continents would become drier and warmer compared to coastal areas, and may face more frequent and intense heat waves. All of these factors have serious implications for global natural and human ecosystems, as well as drastic effects on our economies and worldwide political stability.

The Kyoto Protocol

Countries around the world have recognized the urgent need to take action to reduce greenhouses gas emission in order to address climate change.

In December 1997, Canada and more than 160 other countries met in Kyoto, Japan, and agreed to targets to reduce GHG emissions. The agreement that set out those targets, and the options available to countries to achieve them, is known as the Kyoto Protocol. Canada's target is to reduce its GHG emissions to 6 percent below 1990 levels by the period between 2008 and 2012.

However between 1990 and 2000 Canadian productivity rose, resulting in an increase in emissions of over 20%. This means that in order to meet the Kyoto Protocol, the total decrease in emissions is now over 20% below 2000 levels. Canada ratified the agreement along with all major trade partners other than the United States. Plans are now being implemented to decrease greenhouse gas emission.

A significant part of the national climate change strategy is for communities to reduce their GHG emissions. There are increasingly more sources of funding, information, and support available to communities to do so.

Calculating eCO2 from Communities

The first step in planning for community reductions in greenhouse gases it to measure current and past GHG emissions. From these estimates, it is possible to set emissions reduction targets and then measure progress over time. It is possible to (approximately) calculate community GHG emissions from the following greenhouse gas sources:

- **Electricity consumption** - although many people see electricity as a "clean" energy source, it actually indirectly is a source where many GHGs are emitted, as Nova Scotia generates 90% of its power from fossil fuels (mostly coal). We use electricity everyday to perform practical activities such as turning on lights, powering appliances, providing heat and providing air-conditioning.

- **Fuel oil & Propane consumption** - Oil and propane gas are used to heat our homes, and propane is sometimes used in propane stoves to cook food. Acadia University uses a type of fuel called Bunker "C" fuel, which is burned to produce steam used to heat the university. Both oil and propane emit GHGs.
- **Transportation fuel consumption** - There are two main sources of fuel used for transportation which are gasoline and diesel. Diesel is used generally to fuel transport trucks, buses, and farm tractors. For the average car gasoline is generally used. Both of these sources of fuel emit large amounts of GHGs
- **Natural gas consumption** - Natural gas for heating homes is not used in Wolfville, though it is a significant source of GHGs in other communities.
- **Firewood consumption** - People burn wood as a source of primary and secondary heat through wood stoves and fireplaces. Though wood is not a fossil fuel, it was included in this study because burning wood releases GHGs and contributes to air pollution.
- **Landfill emissions** – All waste that is collected ends up in either a landfill or in a recycling centre, and all waste-related activities generate GHGs. Of these, it is possible to calculate the GHGs that are emitted from landfills.

Ideally, communities would also calculate the GHG emissions from "upsteam" processes – manufacturing, agriculture and transportation required to bring us our food, clothing, building materials, and consumer products. However, this is currently very difficult to do, and so emissions calculations are simplified by only considering these emissions sources.

Various conversion factors let us calculate the amount energy consumed with each of the energy sources above. For example, 90% of electricity in N.S. is generated by burning coal. There is a simple chemical relationship between the amount of coal burned and the corresponding emission of carbon into the atmosphere. Other greenhouse gases like methane (CH4) and nitrogen oxide (N2O) are emitted in addition to carbon dioxide. A simple a conversion factor lets us combine all three greenhouse gases, CO2, CH4 and N2O under an inclusive unit of "eCO2" ("equivalent CO2") emissions. This is the unit that will be used in the presentation of data.

The Purpose of this Study

The objective of this study was to calculate the eCO2 emissions (combined global warming potentials for CO2, CH4 and N2O) for the Town of Wolfville for the year 2003. The study created an inventory of emissions data from different sectors of the community:

- Residential
- Commercial ("businesses")
- Municipal Government Operations
- Acadia University

Conducting this study will enable the community to strategically reduce eCO2 emissions in each sector. By establishing an energy and emissions inventory for the Town of Wolfville, the community can establish an emissions target for the future. Community stakeholders can develop an action plan for meeting the target and implement the necessary policies in order to attain its targets. The study will also enable us to compare Wolfville with other communities in terms of our eCO2 emissions and determine the financial cost to the community. With this information we can calculate the amount of money the town can save by reducing eCO2 emissions. In the big picture, this study is about working toward a reduction of greenhouse gas emissions and attaining Canada's Kyoto goal, starting with our community

In addition to GHG emissions, this study also found supplementary data on air pollution and traffic congestion, which, though they do not directly contribute to climate change, strongly influence population health and quality of life in a community. This information was collected in the hope that similar indicators can be used in the future to monitor progress toward meeting GHG emissions reduction targets..

Results

Errors, Assumptions, and Estimates

Calculating GHG emissions is a very rough science. Numerous assumptions and estimates were made because direct data was not available, and because door-to-door energy use surveys were not an option. Some calculations were made using national or provincial energy use data, which may or may not apply to Wolfville. For a more detailed evaluation of assumptions and estimates, please see the Technical Notes in Appendix A, or view the data directly. There were insufficient resources in conducting this study to provide estimates of error.

Note that in nearly all cases, however, estimates were made on the conservative side. It is highly likely that actual energy usage was significantly higher than what is reported here. In addition, due to the fact that food, manufacturing, and other "upstream" sources of energy use were not considered, this study provides a conservative estimate of the actual amount of energy needed to sustain the population of Wolfville.

Energy Usage

Energy usage was calculated from a variety of sources, and is shown in Table 1. Electricity use is most accurate, as data was gathered from Nova Scotia Power, Town of Wolfville, and Acadia University. Fuel Oil use data was gathered from the Town of Wolfville and Acadia University, and was estimated for the rest of the community using national and provincial fuel oil and propane data. Natural gas is not used by the community, as no natural gas pipeline exists to this region. Transportation fuel use data was gathered from Acadia University and Town of Wolfville, and was estimated for the rest of the community through field studies of vehicle efficiency, and national statistical information about vehicle use. Firewood use for the community was estimated through communications with local firewood suppliers, and estimates of firewood consumed per household. Landfill waste data was gathered from Town of Wolfville and Acadia University, and community waste estimates were gathered by Valley Waste Resource Management These figures translate into a total energy use of 579,258 GigaJoules for 2003, or 71 GigaJoules per person..

Category	Residents	Businesses	Municipal	Acadia residents	Acadia Total	Community Total
Electricity (kWh)	20,543,863	5,232,628	2,318,772	3,719,323	16,632,313	44,727,576
Fuel Oil (L)	2,618,370	666,912	39,679	1,229,919	4,395,581	7,720,542
Natural Gas (cum)	0	0	0	0	0	0
Transportation (L)	2,017,867	0	70,817	151,763	171,288	2,259,972
Wood (cords)	1,341	0	0	0	2	1,342
Landfill (t)	950	242	51	62	216	1,459

Table 1 - Total Usage of Energy Sources by Sectors of Wolfville Community (2003)

Greenhouse Gas Emissions - Totals

Each energy source usage was converted into an equivalent CO2 value by means of chemical conversion tables, which were supplied by the Federation of Canadian Municipalities, the Partners for Climate Protection Program, Voluntary Challenge and Registry, and the Nova

Scotia Department of Energy. Nova Scotia-specific values were used wherever possible. The results for emissions are tabulated in Table 2, and displayed in Figures 1 and 2. Emissions figures contain a high degree of precision, as conversion figures are well established.

Category	Residents	Businesses	Municipal	Acadia residents	Acadia Total	Community Total
Electricity	18,387	4,683	2,075	3,329	14,886	40,031
Fuel Oil	6,962	1,773	112	3,801	13,474	22,322
Natural Gas	0	0	0	0	0	0
Transportation	4,814	0	180	358	437	5,431
Wood	299	0	0	0	0	299
Landfill	865	220	46	57	196	1,328
Total	**31,327**	**6,677**	**2,414**	**7,544**	**28,993**	**69,411**
Per Capita	5.4	54.3	0.3	4.4	6.5	8.5

Table 2 - Total eCO2 Emissions in Wolfville Community (2003) in tones.

Total Emissions: 69,411 tonnes eCO2

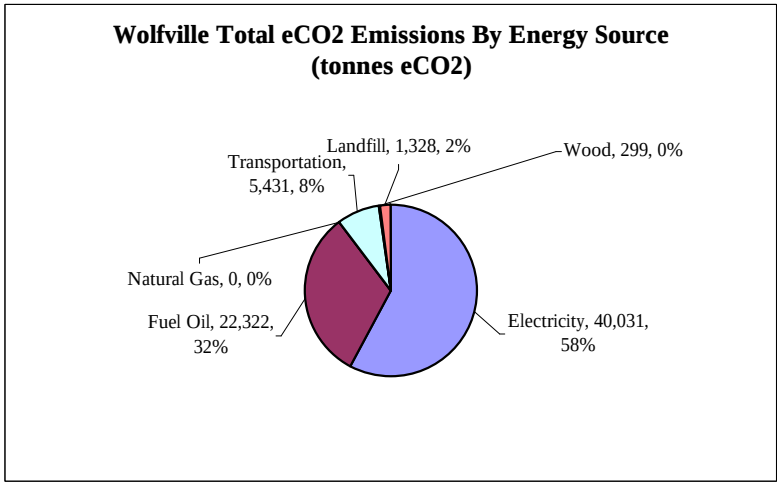

Figure 1 – Wolfville Total eCO2 Emissions by Energy Source

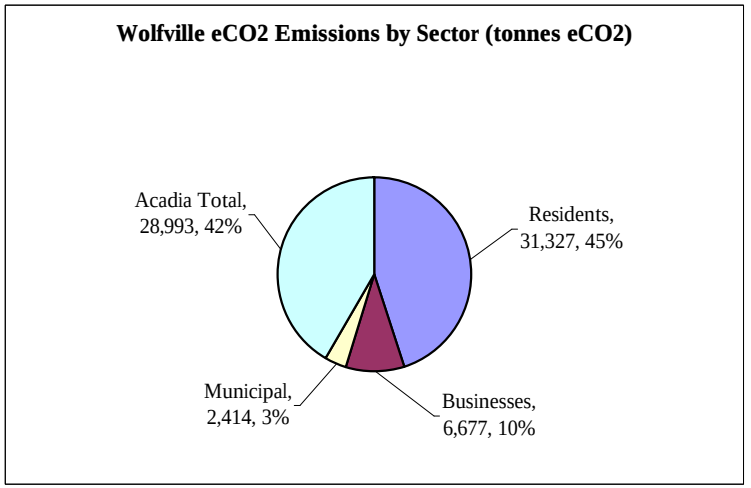

Figure 2 – Wolfville eCO2 Emissions by Sector

Greenhouse Gas Emissions – By Energy Source

Figures 3 – 6 show eCO2 emissions by energy source, and totals. The study shows that the two most significant sources of GHG emissions were electrical use at Acadia University and among community residents, and fuel oil use at Acadia University.

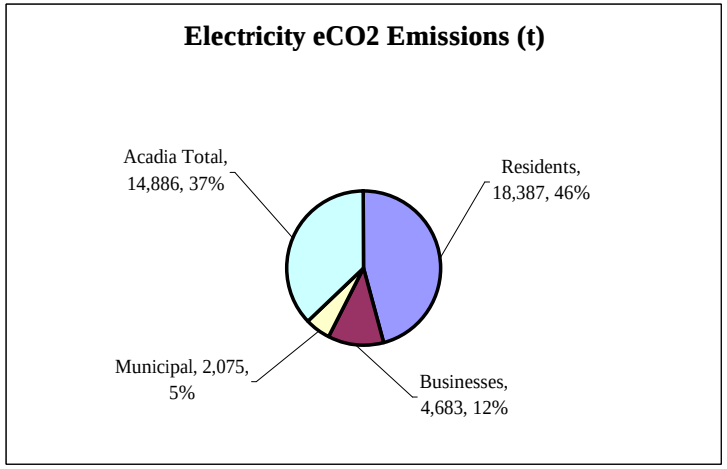

Figure 3 - Total Electricity Emissions: 40,031 tonnes eCO2 (58%)

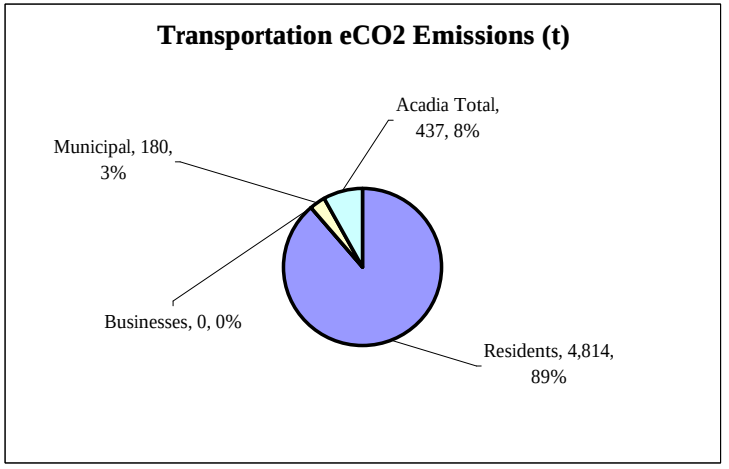

Figure 5 - Total Transportation Emissions: 5,431 tonnes eCO2 (8%)

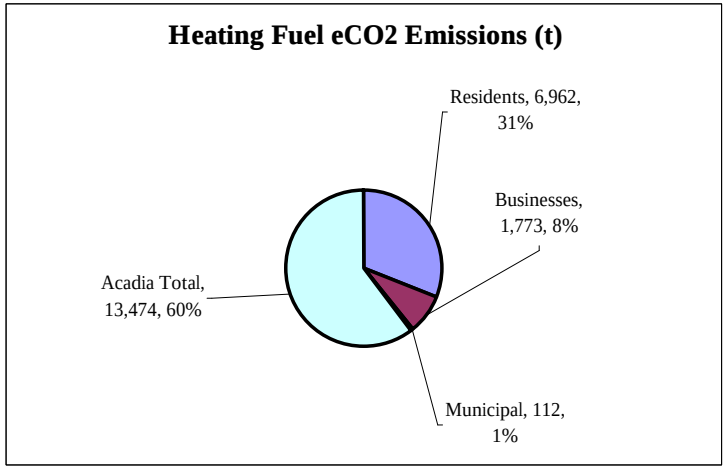

Figure 4 - Total Heating Fuel Emissions: 22,322 tonnes eCO2 (32%)

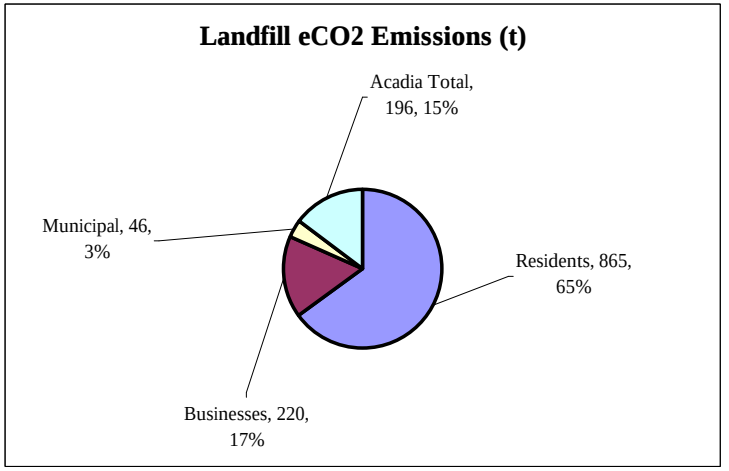

Figure 6 - Total Landfill Emissions: 1,328 tonnes eCO2 (2%)

Greenhouse Gas Emissions – Acadia University

Figures 7 and 8 show eCO2 emissions by Acadia University, and the financial costs of purchasing those energy sources. Producing nearly half of the community's GHG emissions, Acadia University bears a

significant responsibility in reducing the community's overall GHG output.

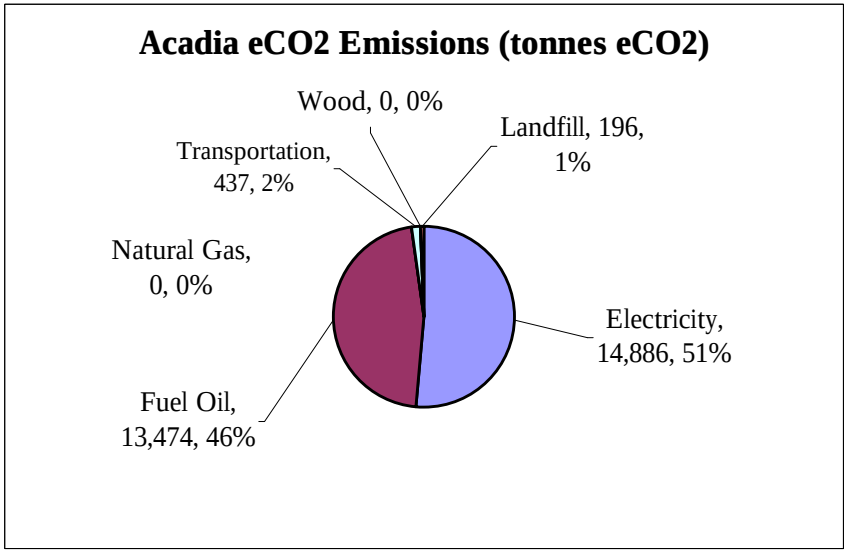

Figure 7 – Acadia University Total Emissions: 28,993 tonnes eCO2

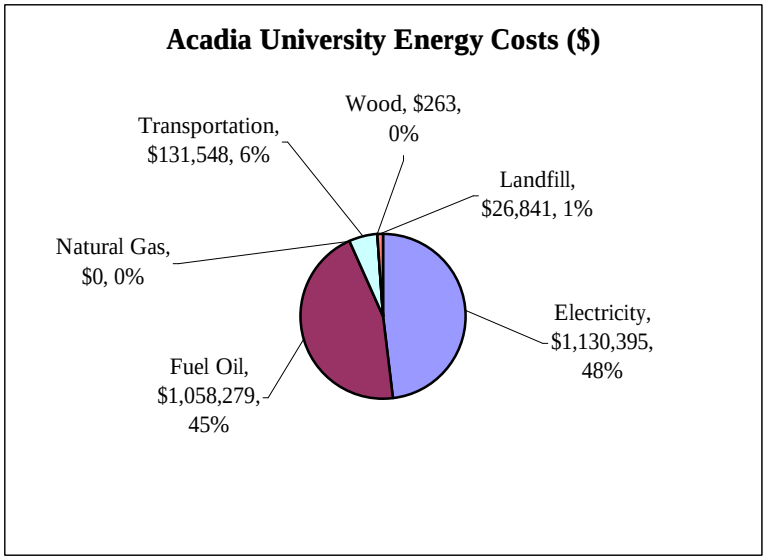

Figure 8 – Acadia University Total Energy Costs: $ $2,347,326

Greenhouse Gas Emissions – Per Capita Comparisons

One of the utilities of conducting GHG emissions studies is that they can be compared between communities. In Canada, much work has been accomplished in calculating national and provincial GHG emissions, and these figures provide points for comparison with Wolfville. Unfortunately, few individual communities have conducted GHG emissions studies to date. To provide a reference point, Wolfville was compared to the resort municipality of Whistler, BC, which released a GHG analysis study in 2004. There are two kinds of GHG emissions statistics provided in Figure 9: "domestic" emissions figures consider only direct energy use within a community, whereas "total" emissions figures include all agricultural, industrial, and transportation emissions, and are therefore much higher and closer to the actual emissions of a population.

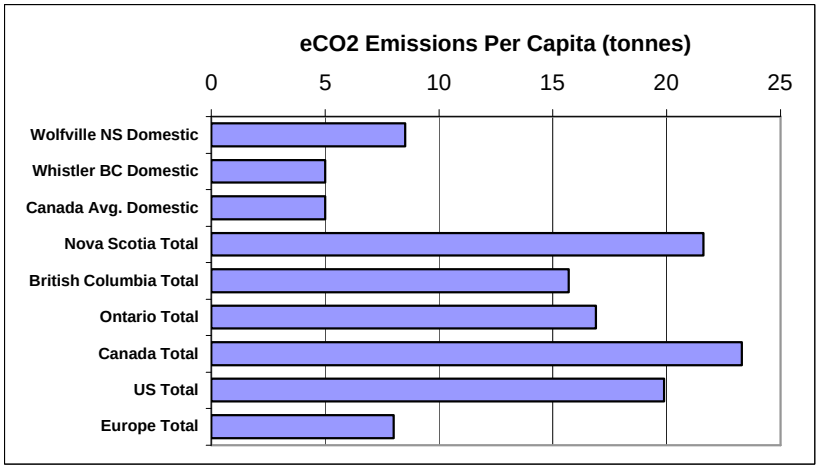

Figure 9 – domestic and total eCO2 emissions per capita in Wolfville and other selected communities

Financial Costs

Financial costs for energy consumption were also found, and are tabulated in Table 3. The table shows that in 2003, nearly $10,000,000 left the community to purchase "fossil fuel services" and generate pollution and climate change impacts. Per capita costs are significant as well.

Electricity costs are most accurate, as data was gathered from Nova Scotia Power, Town of Wolfville, and Acadia University. Fuel Oil use costs were gathered from the Town of Wolfville and Acadia University, and were estimated for the rest of the community based on the market values of these fuels. Transportation fuel use data was gathered from Acadia University and Town of Wolfville, and the costs were estimated for the rest of the community based on market values of these fuels. Firewood costs for the community were estimated based on the market value of wood. Landfill costs were gathered from Town of Wolfville and Acadia University, and community waste cost estimates were gathered by Valley Waste Resource Management, based on tipping fees and municipal funding.

Category	Residents	Businesses	Municipal	Acadia residents	Acadia Total	Community Total
Electricity	$2,338,545	$595,639	$179,085	$252,913	$1,130,395	$4,243,664
Fuel Oil	$1,575,139	$401,196	$15,962	$322,564	$1,058,279	$3,050,575
Natural Gas	$0	$0	$0	$0	$0	$0
Transportation	$1,571,145	$0	$39,138	$118,375	$131,548	$1,741,831
Wood	$234,588	$0	$0	$0	$263	$234,850
Landfill	$250,401	$63,778	$4,200	$7,757	$26,841	$345,220
Total	**$5,969,817**	**$1,060,614**	**$238,384**	**$701,609**	**$2,347,326**	**$9,616,141**
Per Capita	$1,022	$8,623	$29	$411	$522	$1,179

Table 3 - Total Cost of Energy Sources by Sectors of Wolfville Community (2003)

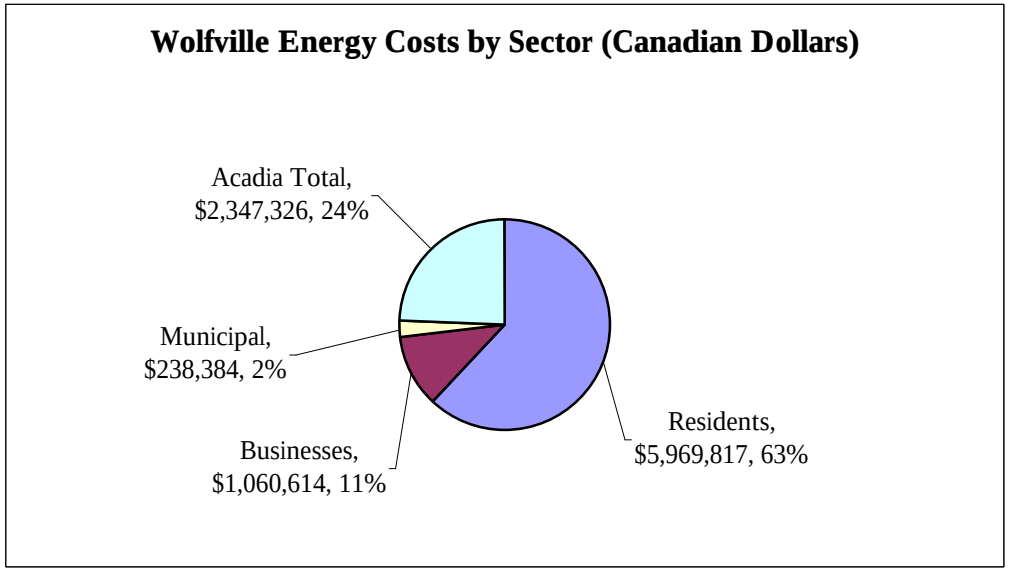

Figure 10 – Wolfville Energy Costs per Sector (Canadian Dollars). Total Energy Cost: **$9,616,141**

Other Indicators: Air Quality & Traffic Condition

Burning energy fuels not only releases GHGs but also various air pollutants. Among other chemicals and heavy metals, the most common emissions of fossil fuels are NOx, SOx, particulate matter, carbon monoxide, and volatile organic compounds (VOC), most of which contribute to acid precipitation, asthma & respiratory irritation, and other negative effects. Table 4 displays calculated NOx and SOx emissions from the generation of Wolfville's electricity (data gathered from Nova Scotia Power).

Pollutant	NOx (t)	SOx (t)
Total	**115.601**	**500.949**
Per Capita (	0.014	0.061

Table 4 - Total Air Pollutant Emissions from Wolfville Electricity Use, in tones

Tables 5 and 6 display statistics on air quality recorded in Kentville in 2003 and 2004. The correlation between the air quality data and the pollution output is not direct, and should not be mistaking for having a proportional relationship, but the idea is to show the possibility for measuring and monitoring these values over time. Table 7 shows ambient air quality ranges that were used in the previous two tables.

Time of day	Quality
9AM	10.23
Noon	11.00
5PM	11.64

Table 5 - Average Ambient Air Quality Index, Kentville, November 1-15 2004

Number of days with fair air (2003)	14
number of day with poor air (2003)	0

Table 6 - Fair and Poor Air Quality Days, Kentville, 2003

quality	Range
good	0 - 25
fair	25 - 50
poor	50 - 100

Table 7 - Air Quality Index Ranges

Finally, Table 8 displays information gathered during 3 days of field studies along Main St. in Wolfville in November 2004 to determine average traffic flow, road congestion, and vehicle efficiencies at 3 different times during the day. The sample sizes were small, and more studies need to be conducted to qualify these results, but the idea is nevertheless sound and can be used to monitor progress toward a climate change neutral community.

Time of Day	Average Vehicle Count (cars/min)	Road Congestion (% time)	Average Vehicle Efficiency (L/100Km)
9AM	14.73	13.33	12.60
Noon	15.50	3.33	13.33
5PM	10.20	0.00	12.95

Table 8 - Road Conditions at Selected Times in Wolfville, November 2004

Recommendations & Conclusions

Continuous GHG Monitoring

The following are recommendations of this report:

- The Town of Wolfville joins a national or international program for addressing climate change, such as the Partners for Climate Protection program managed by the Federation of Canadian Municipalities and the International Centre for Local Environmental Initiatives.
- Monitoring Wolfville's GHG emissions becomes a policy priority for Acadia University and Town of Wolfville. GHG and supplementary indicators should be monitored on a continuous annual basis by Acadia both organizations, and the tools developed and used in this report should be enhanced and fine-tuned.
- Realistic but challenging communit-wide emissions reduction targets are set by Acadia University and Town of Wolfville.
- All stakeholders in the community should work together to implementing actions to reduce the community's GHG emissions, and appropriate public policy should be developed to support this initiative
- To facilitate data collection in the future, researchers should work directly with oil companies and other direct information sources on energy use in the community. Oil companies were found to be resistant to collaborating on this report, and did not provide any information, which is why so many estimates and assumptions had to be made.

Setting a 20% Emissions Reduction Target

As a hypothetical example, the effects of a 20% GHG emissions target are tabulated in Table 9. This report recommends that the community set a strong GHG reduction target, such as 20% by 1012. As the table shows, an annual savings of almost $2,000,000 could be achieved by the community under this scenario. This would be 2 million dollars that would not need to be exported by the community, and would be available to generate other economic services. In addition, a 20% GHG emissions reduction would contribute significantly to reducing Wolfville's climate change impacts, and would set an example for communities across Atlantic Canada.

Sector	Greenhouse Gas Savings (tonnes eCO2)	Savings ($)	Savings per Capita ($)
Residents	6,265	$1,193,963	$204
Businesses	1,335	$212,123	$1,725
Municipal	483	$47,677	$6
Acadia residents	1,509	$140,322	$82
Acadia Total	5,799	$469,465	$104
Community Total	**13,882**	**$1,923,228**	**$236**

Table 9 - Environmental and Financial Savings at a 20% Energy Use Reduction, By Sector

Conclusion

Wolfville's annual GHG output (conservatively calculated) of nearly 70,000 tonnes is contributing to climate change worldwide, and this community's export of nearly $10,000,000 to purchase these services could be better spent on other things.

Despite the shortcomings of this report, and the numerous estimates and assumptions contained within it, it is nevertheless a first attempt at quantifying and monitoring an important and timely issue. Climate change impacts have never before been studied in Wolfville. This report is setting the example for proactive community pollution monitoring, and its recommendations should be heeded.

Appendix A – Technical Notes

This section contains technical notes on how specific calculations were made. All calculations are contained in the digital spreadsheet document named "Wolfville GHG Calculations 2004.xls".

Geographic Area

For the purposes of this study, GHG emissions were calculated based on energy consumption within the geographic area encompassed by the town limits of the Town of Wolfville. This rule applies strictly to all measurements of electrical, fuel oil, propane, and firewood consumption. However, the distinction became blurred when calculating solid waste and transportation emissions because of the difficulty in measuring these elements within tight geographic limits, and are therefore estimates. Future studies should endeavor to focus on containing the study area more tightly.

Consumption Intensity Ratios

Most energy use data was readily available for Acadia University and Town of Wolfville. However, in order to calculate residential and commercial energy use in the remainder of the community, a consumption intensity ratio was developed and used in several energy calculations. The ratio was calculated by calculating the total surface land area used by buildings in the residential and commercial zones of the town. It was assumed that energy use and waste generation would be comparable per unit land area for these two forms of land use. The land areas were calculated using a digital Town of Wolfville zoning map, and using spatial analysis software to calculate the built areas. It was found that of all remaining built land (after municipal and university structures were removed), residential buildings occupied 79% of the land, and commercial buildings occupied 20.3% of the land. Energy use and waste production for these sectors was calculated using these formulas (except for transportation and firewood use, where business sector uses were arbitrarily assigned values of zero, because use was assumed to be negligible compared to residential use.

Electricity Consumption

Town of Wolfville electricity use was partially estimated from electricity costs, as a small proportion of use data was missing, though all the costs were present. The remainder of the kilowatt hour values were generated by calculating the average monthly fee and hourly rate for the data that was present, and then extrapolating these rates to the missing usage values.

Acadia University electrical use and cost data was supplied by the university Physical Plant.

Nova Scotia Power generously supplied billings information for the entire community. Acadia University and Town of Wolfville data were subtracted from these totals, and the remainder was assigned to residential and commercial use through the consumption intensity ratio (roughly 80:20).

Fuel Oil & Propane Consumption

Fuel oil and propane (and Bunker "C" for Acadia) figures were supplied by Town of Wolfville and Acadia University.

For the remainder of the community, researchers consulted data from the Canadian Residential Energy End-use Data and Analysis Centre (CREEDAC) and found the percentage (64%) of Nova Scotia homes that use fuel oil for their main source of heating. The total number of residential units in Wolfville were found on the Statistics Canada website (2001 Census data, also used for numerous other calculations). The number of residential units in Wolfville were multiplied by the

percentage using fuel oil for heating to find the number of residences using fuel oil.. The quantity of fuel oil used per residence was roughly estimated by researchers, and multiplied by the previous figure to find the number of litres of heating fuel consumed by the residential sector in Wolfville. The price of heating oil per liter which was found on the website of the Nova Scotia Department of Energy, by averaging out the daily prices for 2003. The number of litres used by residences was multiplied it by the price of oil per liter to give the total residential cost per year for fuel oil for heating. These figures were then multiplied by the consumption intensity ratio to estimate the amount and cost of heating oil for Wolfville businesses.

For the propane component of the heating section for residences and businesses, researchers found the population of Nova Scotia and also the amount of propane used in Nova Scotia in 2003. They then determined the population ratio (Wolfville / NS) to determine the amount of propane used in Wolfville. To determine total cost, this figure was multiplied it by 80 cents per liter. To determine consumption and cost for Wolfville businesses, these figures were multiplied by the consumption intensity ratio.

Transportation Fuel Consumption

Transportation fuel use and cost data for corporate fleets was supplied by Town of Wolfville and the Acadia University Physical Plant.

University residential and community residential transportation use was difficult to calculate, and is likely the least accurate section of this report. The method used to find this information was as follows:

Passing traffic was observed over 15 minute intervals from 8 am to 8:15 am, 12 noon to 12:15 pm and 5 pm to 5:15 pm on Main Street, near Wolfville's central commercial area. This was done on three different days, a Wednesday, a Friday and a Sunday, to get as much data as possible. Data recorded included traffic counts per minute, the relative congestion of the road, and the class of each vehicle passing by. A list of classes of vehicles was obtained from Natural Resources Canada' vehicle efficiency website. The 11 categories used, sorted according to their fuel efficiency and type, were as follows:

Class	Efficiency (L/100Km)	Fuel Used
2-seater	12.5	gasoline
Sub-compact	10.3	gasoline
Compact	11.8	gasoline
mid-size	12.3	gasoline
full-size	9.5	gasoline
station wagon	10.5	gasoline
pickup truck	15.0	gasoline
SUV	16.0	gasoline
Van	10.8	gasoline
Heavy truck	39.0	diesel
Bus	32.0	diesel

As the vehicles passed, they were counted in one of these categories. The fraction of vehicles in each class was multiplied by their respective fuel efficiencies to determine the average fuel efficiency of a vehicle in Wolfville The average fuel efficiency of the vehicles in Wolfville was then multiplied by an estimated number of vehicles in Wolfville (a minimum value for this was found on Statistics Canada website), and the average amount of driving by Canadians (again from the Statistics Canada website) to determine the total amount of fuel consumed. This figure was multiplied by the average cost of fuel in 2003 (NS Department of Energy) to find the total cost of transportation fuel.

At the same time that the vehicles were being classified according to fuel efficiency, traffic congestion was also being observed. A note was made for every minute out of the 15 that passed where the traffic was not flowing smoothly. We were thus able to get a percentage of time for which the traffic on Main Street was congested.

Wolfville businesses were arbitrarily assigned a transportation fuel consumption of zero, as it would have been difficult to determine the proportion of traffic Wolfville that could be attributed to the driving

that local businesses conducted for business needs. However, it is felt that this value would probably be negligible compared to the transportation needs of residents.

To determine the amount of fuel consumed by students living in residence at Acadia University, a survey was done of the Tower parking lot, where all vehicles were assumed to be owned by Acadia students. Vehicles were counted and sorted according to class, and the same calculations were conducted to determine total fuel consumption and cost, though it is unknown how accurate these values are.

Community Firewood Consumption

Firewood consumption for Town of Wolfville and Acadia University was nonexistent or very small. In order to calculate the cords of wood burned in Wolfville, researchers contacted the three main chimney cleaning businesses for Wolfville and asked them how many chimneys they cleaned per year, to determine the number of homes that used firewood. This figure was multiplied by the average number of cords of firewood burned per household (information gathered from local firewood suppliers) to find the total amount of firewood consumed by residents. This figure was multiplied by the local market price of firewood (gathered from local firewood suppliers) to determine the total cost to the community.

These values were verified and determined to be realistic through internet research.

Landfill Waste Generation

Landfill waste data was acquired from Town of Wolfville and Acadia University. The amount of waste generated by Acadia University residents was assumed to be proportional to the ratio of heat use in residences (28.9%), and was given this ratio of tonnages and costs.

The total amount of waste generated by the community was estimated by Valley Waste Resource Management using the "uniform assessment" ratio for the Town of Wolfville as a percentage of their total service area (5.43%). The total costs to the community were estimated by adding up tipping fees and taxes and again dividng these by Wolfville's uniform assessment percentage. Acadia University and municipal waste tonnages and costs were subtracted from these totals, and the remainders were assigned to the residential and commercial sectors using the consumption intensity ratio.

Conversion Factors

Each energy source usage was converted into an equivalent CO2 value and energy value (in GigaJoules) by means of chemical conversion tables, which were supplied by the Federation of Canadian Municipalities, the Partners for Climate Protection program, Voluntary Challenge and Registry Inc., and the Nova Scotia Department of Energy. Nova Scotia-specific values were used wherever possible. Figures for these conversions are well-established and are thus felt to contain a high degree of accuracy.

In order to calculate other forms of air pollution (NOx, SOx, particulate matter, CO, and VOC), similar conversion factors were sought, but with little success, except for electricity, where the values are published by Nova Scotia Power. These calculations are likely the least accurate in the report, and care needs to be taken when interpreting them. Future GHG studies should update these conversion values appropriately.

Population Figures

Population figures were needed to calculate per capita consumption and cost figures, and were needed in a number of other calculations involving the populations of the different sectors in the community. The following figures were used in this report:

Category	Population
Residents	5,844
Businesses	123
Municipal	8,153
Acadia Residents	1,708
Acadia Total	4495
Community Total	8,153

"Residents" contains both the number of full-time residents in the community (Census 2001 data), as well as the number of students living off-campus in 2003. "Businesses" contains the number of businesses (not people), in Wolfville in 2003, as reported by the Wolfville Business Development Corporation's website. "Municipal" contains the total population of the community, as municipal services are distributed among all residents. "Acadia Residents" contains the total number of students living in residence in 2003, as reported on the Acadia University website. "Acadia Total" includes student residents, as well as an estimate of the number of faculty, staff, and administrators in 2003. "Community Total" includes all members of the community, including all people in the Acadia Total category.

Air Quality Data

Average air quality data for 2003 and 2004 was found on the Environment Canada website. Air quality is good if the AQI values are 25 or less. AQI values from 26 to 50 are fair. AQI values of 51 to 100 are poor. AQI values greater than 100 are very poor.

Appendix B – Information Resources

Local Resources

- Town of Wolfville: www.town.wolfville.ns.ca
- Centre for Rural Sustainability: www.ruralustainability.org
- Acadia University: www.acadiau.ca
- Valley Waste Resource Management: www.vwrm.com

Climate Change

- Government of Canada Climate Change website: www.climatechange.gc.ca
- Intergovernmental Panel on Climate Change: http://www.ipcc.ch
- International Energy Agency: http://www.iea.org/
- World Resources Institute: http://www.wri.org/
- Federation of Canadian Municipalities: http://kn.fcm.ca
- International Centre for Local Environmental Initiatives: www.iclei.org
- Voluntary Challenge & Registry, Inc: www.vcr-mvr.ca

Electricity

- Nova Scotia Power: www.nspower.ca
- Emera Corporation: www.emera.com

Fuel Oil

- Nova Scotia Fuel Oil Prices: www.gov.ns.ca/energy/inside.asp?cmPageID=180

Transportation

- Canadian Automobile Association: Driving Costs Report 2004: www.carpool.ca/pdf/caa-driving-costs-04.pdf
- NRCan Office of Energy Efficiency Fuel Consumption Guide: http://oee.nrcan.gc.ca/vehicles/

Fuel wood

- Residential Wood Heating report, 1998: http://www.omni-test.com/Publications/neworlpap1.pdf
- NRCan Wood Heating Report: http://www2.nrcan.gc.ca/es/oerd/english/view.asp?x=700&mid=31

Air quality

- Environment Canada Air Quality: http://www.atl.ec.gc.ca/airquality/query/

Propane

- NS propane prices: www.gov.ns.ca/energy/inside.asp?cmPageID=233
- Propane Use: http://www.propanegas.ca/files/Propane_Supply_Demand.pdf

Other Information

- Statistics Canada: www.statcan.ca
- Office of Energy Efficiency: http://oee.nrcan.gc.ca
- Canadian Residential Energy End-use Data and Analysis Centre: http://www.dal.ca/~creedac/
- Resort Municipality of Whistler: www.whistler.ca
- ecoPerth, Perth Ontario: http://www.ecoperth.on.ca/
- Nova Scotia Department of Energy: www.gov.ns.ca/energy