

Bowen Island Community Energy Planning

Phase 1: Baseline of Energy Consumption, Greenhouse Gas Emissions, Local Air Pollutants, and Energy Expenditures – 1996, 2000, and 2010

Prepared for the Bowen Island Sustainability Task Force
by the Pembina Institute

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About the Pembina Institute

The Pembina Institute is an independent, citizen-based organization involved in environmental education, research, public policy development, and client-confidential environmental consulting services. Its mandate is to develop and promote policies and practices that lead to environmental protection, resource conservation, and environmentally sound and sustainable energy and resource management. The mission of the Pembina Institute is to implement holistic and practical solutions for a sustainable world. Incorporated in 1985, the Institute's head office is in Drayton Valley, Alberta, with offices in Ottawa and Calgary and satellite offices in Edmonton, Vancouver, and other locations across Canada.

The Pembina Institute's Community Eco-Solutions Program aims to facilitate the planning and implementation of end-use energy efficiency, low-impact renewable energy, and green hydrogen energy in Canadian communities. The Pembina Institute supports community energy planning efforts and provides technical and business expertise on sustainable energy options to client communities including support for engaging project investors.

For more information on the Pembina Institute's work, and details of the capabilities and services offered, please visit our website at <http://www.pembina.org>.

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1 Introduction

Bowen Island is a community of about 3,000 people located in Howe Sound in the Greater Vancouver area, British Columbia. The Pembina Institute was engaged by the Bowen Island Sustainability Taskforce of the Bowen Island Municipal Council to develop an energy and emissions baseline for the entire community.

This baseline report is one of the outputs of a multi-phase project which aims to advance Community Energy Planning (CEP) on Bowen Island. CEP aims to engage local government and citizens in the management and supply of energy. The objectives are to encourage citizens to maximize energy and transportation efficiency, shift transportation modes to less energy-intensive ones, utilize local renewable energy sources, and to reduce wastes, among others. The municipality can promote CEP through its land use and transportation planning procedures, building codes, bylaws, and municipal investments in infrastructure. In addition, local government can help to empower citizen participation in energy and emission management through awareness building efforts and financial incentives.

The project is being managed by the Bowen Island Sustainability Task Force, with support from the Bowen Island Municipality, the Pembina Institute, BC Hydro, the B.C. Energy Aware Committee, Translink, BC Ferries, and a local housing developer. This work was funded jointly by the Bowen Island Municipality and BC Hydro. The funds were administered by the BC Energy Aware Committee.

One of the fundamental goals of this overall project is to position Bowen Island as a leader in the advancement of energy sustainability. This effort could serve as demonstration for other such initiatives in island communities with similar characteristics along the coast of British Columbia.

This report provides a baseline report on emissions and energy use and serves as the first step in community energy planning for Bowen Island. It includes:

- Energy consumption of island residents
- Greenhouse gas emissions
- Other air emissions which can affect air quality and human health
- Approximate energy expenditures of island residents

The baseline provides actual energy consumption data from the year 1996 and 2000 where possible, and a forecast of data for the year 2010. The projections used to predict 2010 energy consumption and emissions is based on a “business as usual” case, that is, current levels of energy use and population growth are assumed to stay relatively constant. The data were gathered from multiple sources as outlined in the “Acknowledgements” section above.

This report is structured with the following chapters:

- Structure of baseline
- Energy consumption
- Greenhouse gas emissions
- Other air pollutants
- Energy expenditures
- Conclusions of baseline development efforts
- Recommendations for next steps

Prior to developing the baseline, the Pembina Institute met with Sustainability Task Force Members to establish community-planning priorities. In addition, several sources of information were reviewed to understand the context of energy consumption on the island.

The baseline modelling was performed by the Pembina Institute using a custom-made spreadsheet. The other alternative available to the project team was to use the Canadian Cities for Climate Protection (CCP) Greenhouse Gas Emissions Software. The advantages and disadvantages of each method, as summarized below, were weighed to determine which modelling technique was used. Ultimately, the versatility of a custom-made spreadsheet to analyze and present the baseline data was the primary motivator behind the decision to not use the CCP software.

The independent development of a spreadsheet from scratch provided the following advantages:

- Complete flexibility in the format of input parameters, assessment tools and outputs. This allows the information to be handled and presented in a variety of formats, thus improving the ability to identify and communicate important findings. This advantage is considered highly significant since the commercial software has a limited number of pre-defined categories and presentation formats, which did not match the desired categories and presentation formats given the unique nature of the Bowen Island baseline.
- Detailed understanding of how the results are generated. Baseline construction and interpretation requires a multitude of information to be collected, compiled and analyzed. Building the entire baseline model allows the user to know how each result category is calculated and avoids the use of “black boxes” where the user is unaware of the calculations used without detailed review of the software. Both methods require sufficient time to understand the calculations used, and this advantage is perhaps more personal preference than anything else.
- Immediately available. There was some difficulty in obtaining the Torrie-Smith software from the identified sources given the many hands it had passed through before the Pembina Institute was hired. Priority was not given to tracking down the software since it was not deemed necessary to begin the data collection process. This was also perhaps more dependent on the specific project situation rather than the characteristics of the two modeling options.

There are also a few disadvantages to developing a spreadsheet from scratch as opposed to using commercial software:

- Calculation errors are expected to be less with the commercial software given the level of review it has undergone. This margin of errors is expected to be small since the spreadsheet has been developed and reviewed by trained technical persons. Similarly, the ease of inputting data is considered higher for the commercial software, however, this was not considered highly necessary for the consultants.
- If the clients would like to perform their own analysis beyond that already completed, the commercial software would likely be the easiest tool to use. This is considered a small disadvantage since the commercial software can still be used by the clients if desired. Data entry should be relatively straightforward now that the input data has been compiled and presented in the baseline report.

The report appendices include a detailed list of assumptions used to develop the Bowen Island energy baseline, a report which can be submitted to the Federation of Canadian Municipalities (FCM) – Partners for Climate Protection program as a Bowen Island submission for 1996 and 2000 data; a list of contacts related to this project; and a copy of the slides used for the community workshop in April, 2002.

A separate baseline has been developed for FCM due to the fact that the boundaries of the following baseline are different than those prescribed by the FCM Partners for Climate Protection program. The specific emission sources that are beyond the FCM boundaries are the ferry and any off-island use of personal vehicles. It was decided by the steering committee that these two sources contribute a significant portion of the emissions created as a result of the activities of Bowen Island residents, and should be included in any baseline that would consequently be used to determine options for emission reductions.

2 Structure of Baseline

The energy and emissions baseline for Bowen Island considers five sectors of activity of Bowen Island residences and visitors:

- Residential
- Commercial / Municipal / Institutional
- Industrial
- Transportation
- Landfills

The residential sector consists of private homes – including single-family dwellings and multi-unit buildings such as condominiums and apartments. Within the residential sector, the specific energy sources for the baseline include fuel-oil use for space heating and water heating, wood use for space heating, and electricity consumption for lighting, heating, appliances, and other uses. Propane use on the island was not quantified due to a lack of willingness on the part of the suppliers to share this information. This gap is not expected to affect the overall results significantly.

The commercial / municipal / institutional sector consists of all fuel oil and electricity consumption on the island that is not part of the residential sector. This includes the island's publicly and privately owned institutions, businesses and services.

The industrial sector is currently limited on the island to construction activities. Unfortunately, the amount of diesel used by contractors on the island proved too difficult to collect. This gap is not expected to significantly affect the overall results.

The transportation sector contains all of the transportation activities used by Bowen Island residents. The methods of transportation that were identified are use of private vehicles (both on-island and off-island) and public transportation (provincial ferry and Bowen Island bus). Off-island public transportation was not considered. In addition, transportation activities of visitors to the island were not included.

Landfills were considered as sources of greenhouse gas emissions created by wastes from Bowen Island.

Agriculture is one sector that is noticeably absent from the energy and emissions baseline. There are typically many methods of energy use and emissions generation within agriculture practices. Data regarding agriculture on Bowen Island were not collected since there is very little agriculture activity currently taking place on the island – a condition that is not expected to change in the foreseeable future. One land practice that was identified as a potential emission source is the burning of forest remnants (slash) left over after land is cleared. The amount of wood burned due to this activity was not quantified, but is only expected to have significant influence on the air pollutant emission inventory results.

3 Energy Consumption Baseline

The following table outlines the energy consumption of Bowen Island residents for the years 1996, 2000, and 2010. The years 1996 and 2000 information are estimates based on actual statistical data sources, while the 2010 information is a projection based exclusively on assumptions. The assumptions used for this data are provided in Appendix A.

Table 3.1 – Annual Energy Consumption

	1996	2000	2010	1996	2000	2010
	GJ	GJ	GJ	% of total	% of total	% of total
Residential						
Fuel Oil	9,200	10,000	13,000	3%	2%	2.4%
Wood	21,000	23,000	30,000	6%	6%	6%
Electricity	84,000	100,000	130,000	24%	25%	24%
Commercial / Municipal / Institutional						
Fuel Oil	1,900	2,000	2,700	0.5%	0.5%	0.5%
Electricity	12,000	15,000	19,000	3.6%	3.6%	3.4%
Industrial						
Construction	5,500	5,600	5,800	2%	1%	1.1%
Transportation						
On-island	24,000	32,000	50,000	7%	8%	9%
Off-island	93,000	120,000	190,000	26%	29%	35%
Ferry	99,000	99,000	99,000	28%	24%	18%
Bus	Assumed to be small based on GHG emission estimate.					
Total	350,000	410,000	540,000			
% increase from 1996		17%	55%			
Annual Growth Rate		4.0%	3.2%			

The following observations can be made regarding energy consumption on Bowen Island:

- Energy consumption has grown by 17% between 1996 and 2000, or about 4.0% per year. This is larger than the estimated total population growth of 9% in the same period.
- Between 1996 and 2010, the growth is expected to be 55%, or about 3.2% per year. This is also larger than the projected total population growth of 41% in the same period.
- The lower energy consumption growth rate in the period from 2000 to 2010 (compared to 1996 to 2000) is attributable to the already significant shift in the transportation vehicle type of residents from cars to sport utility vehicles and minivans between 1996 and 2000. This trend resulted in less efficient vehicles with higher energy consumption. The use of these less efficient vehicles is expected to continue forward, yet the major shift in vehicle type has already occurred.
- An increased number of vehicles per person is another factor in the difference between percentage energy growth and population growth. The total vehicles are estimated to have an annual growth rate of 4.7% between 1996 and 2010.
- Approximately 62% of the total energy consumption on Bowen Island is for transportation, with, on average, 8% of total energy being for on-island transportation, 30% for commuters in private vehicles off-island, and 24% for ferry operation for the three years investigated.
- About 33% of the total energy consumption on Bowen Island is for the residential sector.

- Electricity is responsible for the vast majority of energy needs in buildings, while wood is responsible for approximately 18% of the residential sector, and fuel oil makes up 7% of building energy requirements in the residential sector and 13% in other buildings.
- The commercial, municipal, institutional and industrial sectors consumed only 4% of the island's energy as a result of their relatively small presence on Bowen Island.

4 Greenhouse Gas Emissions Baseline

The following table outlines the greenhouse gas (GHG) emissions of Bowen Island residents for the years 1996, 2000, and 2010. The years 1996 and 2000 information are estimates, while the 2010 information is a projection. Combustion of wood is assumed to be greenhouse gas neutral (ie. the life-cycle of the wood removes as much carbon from the atmosphere as it adds). This assumes that the wood is harvested in a sustainable manner. Other assumptions used for this data are provided in Appendix A.

The global warming potential of the various greenhouse gases is commonly presented in their equivalence to carbon dioxide to affect global warming (using the units “kg CO₂ eq”). The Intergovernmental Panel on Climate Change uses factors of 21 and 310 for the 100-year global warming potential of methane and nitrous oxide respectively.

Table 4.1 – Annual Greenhouse Gas Emissions

	1996 tonnes CO₂ eq	2000 tonnes CO₂ eq	2010 tonnes CO₂ eq	1996 % of total	2000 % of total	2010 % of total
Residential						
Fuel Oil	680	720	960	4%	3%	2.9%
Electricity	350	1,200	2,700	2%	5%	8%
Commercial / Municipal / Institutional						
Fuel Oil	140	150	200	0.7%	0.7%	0.6%
Electricity	52	170	380	0.3%	0.7%	1.2%
Industrial						
Construction	410	410	430	2%	2%	1.3%
Transportation						
On-island	2,100	2,700	4,300	11%	12%	13%
Off-island	7,900	10,300	16,300	41%	44%	49%
Ferry	7,400	7,400	7,400	38%	31%	22%
Bus	40	90	90	0.2%	0.4%	0.3%
Landfills						
Port Mann	68	74	96	0.4%	0.3%	0.3%
Cache Creek	150	170	220	0.8%	0.7%	0.7%
Total	19,000	23,000	33,000			
% increase from 1996		22%	72%			
Annual Growth Rate		5.0%	3.9%			

The following observations can be made regarding energy consumption on Bowen Island:

- GHG emissions have grown by 22% between 1996 and 2000, or about 5.0% per year.
- Between 1996 and 2010, the growth is expected to be 72%, or about 3.9% per year.
- The lower growth rate in the period from 2000 to 2010 is attributable to the already significant shift in vehicle type from cars to sport utility vehicles and minivans between 1996 and 2000.

- About 88% of the total GHG emissions on Bowen Island are from transportation, with, on average, 12% of total emissions from on-island transportation, 45% from commuters in private vehicles off-island, and 31% for emissions from ferries over the three years investigated.
- Emissions from the Bowen Island bus are insignificant.
- About 8% of the total GHG emissions on Bowen Island are from the residential sector.
- The commercial, municipal, institutional and industrial sectors produced only 3% of the island's GHG emissions.
- GHG emissions from electricity have increased nearly 3 times between 1996 and 2000, and are expected to more than double above 2000 levels by 2010. These numbers are linked to the GHG intensity for electricity generation (i.e., the amount of GHG emissions per unit of electricity produced) in the province. The most recent projection for 2005 has been used as an estimate for 2010 emission factor. However, GHG intensity is expected to further increase in British Columbia between 2005 and 2010; therefore, this is a low estimate.

5 Baseline of Other Air Pollutant Emissions

The following table outlines the emissions of select air pollutants by Bowen Island residents for 1996. Assumptions used for this data are provided in Appendix A.

Table 5.1 –Air Pollutant Emissions on Bowen Island for 1996

Emissions	Units	PM	PM10	PM2.5	CO	VOC	NOX	SOX
Fuel oil - residential	tonnes	0.07	0.04	0.02	0.14	0.02	0.53	0.83
% of total		0.2%	0.2%	0.10%	0.03%	0.03%	0.3%	5%
Wood - residential	tonnes	18	18	17	140	26	1.7	0.2
% of total		59%	73%	74%	25%	35%	1%	1%
Electricity - residential	tonnes	0.07	N/D	N/D	0.07	0.05	0.15	0.02
% of total		0.2%	-	-	0.01%	0.06%	0.08%	0.13%
Fuel oil - commercial	tonnes	0.01	0.01	0.00	0.03	0.00	0.11	0.17
% of total		0.05%	0.03%	0.02%	0.005%	0.006%	0.1%	1%
Electricity - commercial	tonnes	0.004	N/D	N/D	0.005	0.003	0.010	0.001
% of total		0.014%	-	-	0.001%	0.004%	0.006%	0.009%
Construction Equipment	tonnes	0.4	0.4	0.4	2.0	0.4	5.4	0.1
% of total		1%	2%	2%	0.4%	0.6%	3%	1%
Construction Activity	tonnes	5.7	0.12	0.02	N/A	N/A	N/A	N/A
% of total		19%	0.5%	0.10%	-	-	-	-
Personal Vehicles – On-Island	tonnes	0.23	0.22	0.15	82	9.0	8.5	0.33
% of total		0.7%	0.9%	0.66%	15%	12%	5%	2%
Personal Vehicles – Off-Island	tonnes	0.86	0.84	0.57	310	34	32	1.3
% of total		2.8%	3.3%	2.49%	57%	46%	18%	7%
Ferry	tonnes	5.2	5.2	4.8	16.7	5.4	130	14
% of total		17%	21%	21%	3%	7%	73%	82%
Total	tonnes	31	25	23	547	75	177	17

N/D – No data available

N/A – Not applicable

The following observations can be made regarding air pollutant emissions on Bowen Island:

- Particulate matter (PM), which is harmful to the respiratory tract and a constituent of smog, has been classified into three sizes: all sizes (PM), smaller than 10 microns (PM10), and smaller than 2.5 microns (PM2.5). Simply put, the smaller the particle size, the deeper into the lungs that the particle can penetrate and, resultantly, the more potential damage it can cause. Wood combustion emits the majority of particulates in all three categories (59% of PM, 73% of PM10, and 74% of PM2.5). Coarse particulate matter from construction activity on the island is estimated to account for 19% of the PM emissions, but very little of the finer particles. The ferry accounts for the majority of the remaining particulate matter emissions for all size categories.
- Carbon monoxide (CO), which impairs the body's ability to deliver oxygen to cells, is emitted in the largest quantity of all the air pollutants investigated. Vehicles and wood combustion are responsible for 72% and 25% of total CO emissions respectively.

- Volatile organic compounds (VOC), which contribute to ground level ozone or “urban smog” (harmful to the respiratory tract and plant productivity; a constituent of smog) and PM formation, are emitted primarily through vehicle operation and wood combustion– amounting to 58% and 35% of total VOC emissions respectively.
- Nitrogen oxides (NO_x), which are harmful to the respiratory tract, contribute to acid deposition, and are a precursor to ground level ozone (i.e., “smog”) and PM creation, are emitted primarily by the ferry (73% of total NO_x emissions). Personal vehicles also contribute 23% of the total NO_x emissions.
- Sulphur oxides (SO_x), which are harmful to the respiratory tract, contribute to acid deposition, and are a precursor to PM creation, are emitted primarily by the ferry (82% of total SO_x emissions). Personal vehicles also contribute 9% of the total SO_x emissions.
- The burning of forest remnants (slash) from the clearing of land was not quantified in this baseline. It is unclear whether this emission source would influence the air emissions inventory results, but the types of emissions are likely comparable to the wood combustion emissions described above.

6 Baseline of Energy Expenditures

The following table outlines the energy expenditures of Bowen Island residents for the years 1996, 2000, and 2010. The years 1996 and 2000 information are estimates, while the 2010 information is a projection. All of the unit energy costs are based on current prices. Assumptions used for this data are provided in Appendix A.

Table 6.1 – Annual Energy Expenditures

	1996	2000	2010	1996	2000	2010
Residential			\$ per dwelling (for primary use)			
Fuel Oil	\$ 140,000	\$ 160,000	\$ 200,000	\$ 420	\$ 420	\$ 420
Wood	\$ 240,000	\$ 260,000	\$ 340,000	\$ 600	\$ 600	\$ 600
Electricity	\$ 950,000	\$ 1,200,000	\$ 1,500,000	\$ 980	\$ 1,100	\$ 1,100
Commercial / Municipal / Institutional			\$ per building			
Fuel Oil	\$ 30,000	\$ 32,000	\$ 42,000	\$ 420	\$ 420	\$ 420
Electricity	\$ 100,000	\$ 110,000	\$ 140,000	\$ 1,400	\$ 1,400	\$ 1,400
Industrial						
Construction	\$ 85,000	\$ 86,000	\$ 90,000			
Transportation			\$ per vehicle			
On-island	\$ 430,000	\$ 570,000	\$ 900,000	\$ 250	\$ 270	\$ 270
Off-island	\$ 1,600,000	\$ 2,100,000	\$ 3,400,000	\$ 930	\$ 1,000	\$ 1,000
Ferry Fuel	\$ 990,000	\$ 990,000	\$ 990,000	N/A	N/A	N/A
Total	\$ 4,600,000	\$ 5,500,000	\$ 7,600,000			
% increase from 1996		19%	65%			
Annual Growth Rate		4.5%	3.6%			

The following observations can be made regarding energy consumption on Bowen Island:

- Total energy expenditures have grown by 19% between 1996 and 2000, or about 4.5% per year.
- Between 1996 and 2010, the growth is expected to be 65%, or about 3.6% per year.
- About 68% of the total energy expenditures on Bowen Island are for transportation, with 11% of total costs from on-island transportation, 40% from commuters in private vehicles off-island, and 18% for ferry transportation.
- About 28% of the total energy costs on Bowen Island are for residential buildings.
- For any building, electricity accounts for 64% to 77% of the total energy costs.
- The commercial, municipal, institutional and industrial sectors are responsible for only 1.3% of the island's energy expenditures.
- It should be noted that electricity costs are expected to increase in British Columbia due to the cost of new infrastructure and resources. Thus, the electricity estimates for 2010 are considered low.

7 Summary Conclusions

Through analysis of the energy and emissions baseline for Bowen Island, several important conclusions can be drawn:

- Increased energy consumption and emissions on the island between 1996 and 2010 can be attributed to four main factors:
 - The population is increasing. The annual growth rate is estimated to be 2.2% between 1996 and 2000, and 2.5% between 1996 and 2010.
 - The number of vehicles per resident are increasing. The total vehicles are estimated to have an annual growth rate of 4.7% between 1996 and 2010. This is higher than the population growth estimates.
 - An increased proportion of all vehicles are classified as “light-duty trucks” (i.e., SUVs and minivans). GVRD estimates for 1996 indicate that 71% of vehicles were light-duty cars and 22% were light-duty trucks. Data from the Insurance Company of British Columbia indicate that on Bowen Island in 2000, 52% of vehicles can were classified as light-duty trucks and 40% as light-duty cars. The apparent conclusion is that light-duty trucks have doubled, although the data come from two different sources.
 - Increased amount of electricity from fossil fuels. GHG emission factors for British Columbia were 15 and 42 t CO₂eq / GWh in 1996 and 2000 respectively and are predicted to be 74 t CO₂eq / GWh in 2005 [BC Hydro VCR].
- The off-island operation of vehicles is the largest source of energy consumption and GHG emissions. It also is a significant contributor to CO, VOC, NO_x and SO_x emissions, as well as the largest personal costs to island residents.
- Electricity is the second largest source of energy consumption and the largest cost to the residential and commercial/municipal/institutional sectors. It should be noted that reductions in electricity consumption (i.e., energy conservation or renewable energy use) will have a greater reduction on GHG emissions than the baseline would indicate. The baseline reflects existing sources of electricity, which are dominated by zero-direct-emission hydroelectricity. Natural gas is primarily used for periods of “peak” electricity demand. The vast majority of new power plants will use natural gas. Any reductions of electricity consumption on Bowen Island will arguably reduce generation from existing or new natural gas power plants, given that hydroelectricity is lower cost than gas and can be stored. Thus, although the emissions from electricity were 42 t/GWh in 2000, reductions in electricity demand from Bowen Island would likely reduce production from the Burrard Thermal plant in Port Moody, or some other low efficiency gas plant in the western North American grid, which produce 520 tonnes of GHG emissions per GWh of electricity.
- Ferry operation is the second largest source of GHG emissions and the third largest energy consumer. The ferry is also the largest emitter of NO_x and SO_x, and a significant contributor of PM emissions.
- The on-island operation of vehicles is the third largest source of GHG emissions and one of the largest sources of CO, VOC, NO_x and SO_x emissions on the island.
- Wood combustion in the residential sector is not a net emitter of greenhouse gases, but it is, by far, the largest source of PM emissions and a major contributor to CO and VOC emissions.

8 Recommendations for Next Steps

This report forms a foundation for future Community Energy Planning (CEP) on Bowen Island. It provides a snapshot of energy supply and demand which can be used by the community to determine its best approach in future planning initiatives. The Bowen Island Sustainability Task Force, along with the Bowen Island Municipality, could lead an effort to establish a Community Energy Plan which builds on the information in this report.

The following next steps are recommended for the development of a CEP:

1. Discuss and prioritize CEP objectives with the community. This can include reduction of GHG emissions, improvement of local air quality, or reduction in energy consumption and expenditures, among others.
2. Establish a target for energy and emissions management, e.g., GHG emissions 6% below 1990 levels by 2010, a 10% reduction in 1996 energy consumption in five years.
3. Identify options for reaching the established targets, including the following:
 - a. Improving building and transportation energy efficiency
 - b. Identifying and developing local renewable energy resources
 - c. Encouraging transportation mode shifting (i.e., using different methods to move people such as expanded bus service to off-island locations and encouraging pedestrian modes)
 - d. Shifting municipal government activities toward the encouragement of energy efficient neighborhoods and infrastructure
 - e. Further encouraging reductions and management of waste
4. Perform a technical and financial assessment of potential energy/emission reduction options. Depending on the complexity and cost, both preliminary and detailed assessments may be required.
5. Establish an action plan and budget for the implementation of the aforementioned options.
6. Implement energy/emission reduction activities. A variety of mechanisms can be used to encourage energy/emission reductions in the community. These can include investments by government, policy development, or incentives for community members to take action.
7. Monitor and report on results. The monitoring will also indicate which actions were successful in meeting their objectives and help to prioritize future activities.

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10 Appendix A – Assumptions for Baseline Development

The following tables outline the assumptions used for the baseline development exercise

Table A.1 – Island Statistics

	1995	1996	2000	2010	Assumptions / Sources
Population	2644	2738	2982	3853	'96 [RC], '00 based on actual dwelling growth, '10 assuming constant housing growth based on 34 dwelling starts per year (average from 1990 to 2001), and 2.6 people per dwelling [1996 Census].
% increase from 1996			9%	41%	
Annual Growth Rate			2.2%	2.5%	
Residential / Commercial / Municipal / Institutional Buildings					
Dwellings		1030	1124	1459	'96 [1996 Census], '00 based on actual dwelling growth, '10 assuming constant housing growth based on 34 dwelling starts per year (average from 1990 to 2001) [Bowen Muni]
Portion of buildings that are commercial		6.4%	6.4%	6.4%	Portion of building permits from 1990 to 2001 for commercial [Bowen Muni]
Commercial buildings		70	76	99	Estimate based on portion of building permits and estimate # of dwellings.

Table A.2 – Fuel Oil Assumptions

Factor	Units	95/96	99/00	2010	Assumptions / Sources
Total fuel oil consumption	m3	289	318	409	'96, '00 - [SOBI], '10 - projection based on average dwelling per consumption and # of dwellings in 2010.
Average per dwelling	m3 / dwelling	0.28	0.28	0.28	'10 assumes 0.28 m3 of fuel oil per dwelling continues
Primary fuel oil use	dwellings	340	371	481	Assumes those dwellings without primary wood use. For commercial sector, all commercial buildings assumed to use fuel oil.
Emission factor	t CO2 / m3	2.8	2.8	2.8	
GHG emissions - total	t CO2eq.	820	902	1,159	
GHG emissions - residential	t CO2eq.	680	748	961	
GHG emissions - commercial	t CO2eq.	140	154	198	
Energy cost	\$ / building	\$ 420	\$ 423	\$ 419	
Energy - residential	GJ	9,154	10,073	12,940	
Energy - commercial	GJ	1,885	2,074	2,665	

Table A.3 – Electricity Assumptions

Factor	Units	95/96	99/00	2010	Assumptions / Sources
Total residential consumption	MWh	23,303	28,363	36,832	96, '00 - [BC Hydro], '10 calculated based on # of customers & avg consumption
# of residential customers	accounts	1,468	1,583	2,056	96, '00 - [BC Hydro], '10 calculated based on # of residents & accounts per resident
Residential accounts per resident		0.54	0.53	0.53	'10 assumes average of 95/96 and 99/00
Avg. consumption per residential customer	MWh / account	15.9	17.9	17.9	'10 - assumes same consumption as 99/00
Total commercial consumption	MWh	3,465	4,149	5,186	96, '00 - [BC Hydro], '10 calculated based on # of customers & avg consumption
# of commercial customers	accounts	149	181	223	96, '00 - [BC Hydro], '10 calculated based on # of residents & accounts per resident
Commercial accounts per resident		0.14	0.16	0.15	'10 assumes average of 95/96 and 99/00
Avg. consumption per commercial customer	MWh / account	23.3	22.9	23.3	'10 - assumes same consumption as 99/00
Emission factor	t CO2 / MWh	0.015	0.042	0.074	[BC Hydro - VCR] 1996 value used for 95/96, 2000 value used for 99/00, projection for 2005 used for 2010
GHG emissions - total	t CO2eq.	402	1,366	3,109	
GHG emissions - residential	t CO2eq.	349.5	1,191.2	2,725.6	
GHG emissions - commercial	t CO2eq.	52.0	174.3	383.8	
Energy Cost - residential	\$ / account	\$ 980	\$ 1,106	\$ 1,106	
Energy Cost - commercial	\$ / account	\$ 1,436	\$ 1,415	\$ 1,436	
Energy - residential	GJ	83,891	102,107	132,595	
Energy - commercial	GJ	12,474	14,936	18,669	

Table A.4 – Wood Assumptions

Factor	Units	1996	2000	2010	Assumptions / Sources
Primary wood use	dwellings	340	371	481	'00 - [GVRD - RS], '96 & '10 based on # of dwellings and primary to occasional ratio stated for 2000.
Occasional wood use	dwellings	340	371	481	
Portion of primary users		33%	33%	33%	Compromise between David McEachern's estimate (25% primary & 25% occasional) and Alan Still's estimate (40% primary & 30% occasional)
Portion of occasional users		33%	33%	33%	
Wood consumption - primary	kg / yr / dwelling	3,000	3,000	3,000	1,000 dry kg wood = 1 cord [GVRD - RS]
Wood consumption - occasional	kg / yr / dwelling	500	500	500	[GVRD - RS]
Emission factor	kg CO ₂ eq / t wood	1,576	1,576	1,576	[GVRD/FVRD]
GHG emissions	t CO ₂ eq.	1,875	2,046	2,656	
Energy Cost - primary	\$ / dwelling	\$ 600	\$ 600	\$ 600	
Energy Cost - occasional	\$ / dwelling	\$ 100	\$ 100	\$ 100	
Energy	GJ	21,414	23,368	30,333	

Table A.5 – Construction Assumptions

Factor	Units	95/96	99/00	2010	Assumptions / Sources
Diesel for construction	m ³	142	144	151	'96 & '00 from fuel suppliers, '10 5 year average from 1995 to 2000 [SOBI]
Emission Factor	kg CO ₂ eq / m ³ diesel	2,856	2,856	2,856	[GVRD/FVRD]
Total GHG emissions	tonnes CO ₂ eq.	406	411	431	
Energy Cost - total	\$	\$84,490	\$85,680	\$89,845	
Energy	GJ	5,493	5,570	5,841	
Cement					No information obtained on the amount of cement used in construction activities. 1 tonne CO ₂ / tonne cement produced.

Table A.6 – Personal Transportation Assumptions

Personal Transportation	Units	1996	2000	2010	Assumptions / Sources
Number of vehicles		1,771	2,118	3,347	'95 [GVRD web], '00 [ICBC], '10 calculated based on vehicles per resident
vehicles per resident		0.65	0.71	0.87	'10 linear projection from '96 and '00 calculated values
Distance					
Average per vehicle	km/yr	17,500	17,500	17,500	Estimate based on survey data for the Lower Fraser Valley in 1995. [SAE]
Total	million km	31	37	59	
Vehicle type		[GVRD/ FVRD]	[ICBC] Active policies 31/12/01		
LDGV		70.6%	39.7%	39.7%	Gasoline light duty passenger vehicles.
LDGT1		21.5%	52.4%	52.4%	Gasoline pickup trucks and vans. (ICBC data incl. stationwagons and SUVs)
LDGT2		1.8%	1.8%	1.8%	Motorhomes.
HDGV		0.0%	0.0%	0.0%	Assumed no gasoline trucks or buses over 3856 kg GVW.
MC		1.5%	1.5%	1.5%	Motorcycles
LDDV		3.4%	3.4%	3.4%	Diesel light duty passenger vehicles.
LDDT		0.9%	0.9%	0.9%	Disel pickup trucks and vans.
HDDV		0.3%	0.3%	0.3%	Buses.
Emissions / Cost / Energy Consumption					
Emission Factor	g CO ₂ eq/km	322	352	352	
Total GHG emissions	tonnes CO ₂ eq.	9,982	13,048	20,618	
Energy cost per vehicle	\$/vehicle	\$1,177	\$1,282	\$1,282	
Energy	GJ	117,374	152,786	241,426	
On-island portion					
Average distance - East	km	3	3	3	
Portion of population - East		67%	67%	67%	
Average distance - West	km	9	9	9	
Portion of population - West		33%	33%	33%	
Avg number of round trips per day		1	1	1	
On-island travel per car	km/yr	3,650	3,650	3,650	
Total GHG emissions	tonnes CO ₂ eq.	2,082	2,721	4,300	
Energy cost per vehicle	\$/vehicle	\$246	\$267	\$267	
Energy	GJ	24,481	31,867	50,355	

Table A.7 – Public Transportation Assumptions

Public Transportation	Units	1996	2000	2010	Assumptions / Sources
Ferry					
Diesel fuel consumption	1000 litres	2,570	2,570	2,570	1998 - 2001 average (only 3.5% uncertainty on amount) [BC Ferries] Vessel and trip frequency was the same in 1996. New vessel with 50% greater capacity planned, but due to more efficient hull and engine design, it is assumed that diesel consumption will not change significantly.
Emission factor	kg CO ₂ eq / kL diesel	2,871	2,871	2,871	[GVRD/FVRD]
Total GHG emissions	tonnes CO ₂ eq.	7,381	7,381	7,381	
Number of vehicles transported		426,909	465,016	600,822	Oct'00-Sep'01 [BC Ferries]
Average GHG per vehicle	kg CO ₂ eq.	17.3	15.9	12.3	
Number of passengers transported	1000 people	1,034	1,126	1,455	'00 - based on Oct'00-Sep'01 actual volumes [BC Ferries] '96 & '10 - based on population
Average GHG per passenger	kg CO ₂ eq.	7.1	6.6	5.1	
Number of round trips		5,527	5,527	5,527	'00 - based on Oct'00-Sep'01 actual volumes [BC Ferries] '96 & '10 - based on population
Average GHG per trip	kg CO ₂ eq.	1,335	1,335	1,335	
Total cost to passengers	\$1000 / yr	\$11,483	\$12,508	\$16,161	
Total fuel costs	\$1000 / yr	\$ 990	\$ 990	\$ 990	'00 [BC Ferries], '96 & '10 assumes constant energy use
Total Energy	GJ	99,420	99,420	99,420	
Bus					
Round trips per weekday		4	9	9	
Total distance of routes	km	35	35	35	
Total distance	km/yr	35,984	80,964	80,964	
Emission factor	g CO ₂ eq / km	1114	1114	1114	assumes heavy duty diesel vehicle over 3856 kg GVW
Total GHG emissions	tonnes CO ₂ eq.	40	90	90	

Table A.8 – Landfill Assumptions

Landfill	1995	1996	2000	2010	Assumptions / Sources
Port Mann (tonnes CO ₂ eq.)	66	68	74	96	'95 [GVRD/FVRD], other years assume a constant contribution per person
Cache Creek (tonnes CO ₂ eq.)	149	154	168	217	'95 [GVRD/FVRD], other years assume a constant contribution per person

Table A.9 – Air Pollutant Assumptions

Emissions	Units	PM	PM10	PM2.5	CO	VOC	NOX	SOX
Fuel Oil								
Emission factors [GVRD/FVRD]	kg / m3	0.3	0.165	0.1	0.6	0.085	2.2	3.448
average per building	kg / building	0.06	0.03	0.02	0.11	0.02	0.42	0.65
Wood								
Emission factors [GVRD/FVRD]	kg / t wood	15.3	15.3	14.23	115.4	21.9	1.4	0.2
average per household	kg / dwelling	39.8	39.8	37.1	300.5	57.0	3.6	0.5
Electricity								
Emission factors [BC Gov]	t / MWh	3.00E-06	N/D	N/D	3.10E-06	2.20E-06	6.80E-06	1.00E-06
average per customer	kg / customer	0.03			0.03	0.02	0.07	0.01
Construction Equipment								
Emission factors [GVRD/FVRD]	kg / m3 diesel	2.81	2.81	2.58	14	3.15	37.7	0.9
Construction Activity								
Emission factors [GVRD/FVRD]	kg / \$1000 activity	0.75	0.016	0.003	N/A	N/A	N/A	N/A
Personal Vehicles								
Emission factors [GVRD/FVRD]	g/km	0.03	0.03	0.02	12.62	1.40	1.31	0.05
average per vehicle	kg/ vehicle	0.6	0.6	0.4	220.9	24.4	23.0	0.9
Ferry								
Emission factors [GVRD/FVRD]	kg/kL	2	2	1.8	6	2.1	49	5.3

N/D – No Data

N/A – Not Applicable

Table A.10 – Unit Energy Costs

Energy	Units	Value	Reference
Gasoline	\$ / litre	0.575	2000 average [Energy Statistics Handbook, Statistics Canada, Oct. 2001]
Diesel	\$ / litre	0.595	2000 average [Energy Statistics Handbook, Statistics Canada, Oct. 2001]
Wood	\$ / tonne	200	educated guess
Fuel Oil	\$ / litre	0.595	assumed to be the same as diesel cost
Electricity	\$ / kWh	0.062	Jan. 2001 rate (incl. gst)
	\$ / account / mo.	7.77	Jan. 2001 charges (incl. gst)
Ferry	\$ / passenger	4.50	Lowest possible regular fair. www.bcferries.bc.ca/fares/horseshoe_bay-bowen_island.html
	\$ / vehicle	16.00	Lowest possible regular fair. www.bcferries.bc.ca/fares/horseshoe_bay-bowen_island.html

Table A.11 – Unit Energy Contents (Lower Heating Value)

Energy	Units	Energy Content
Gasoline	MJ / litre	32
Diesel	MJ / litre	38.68
Wood	MJ / kg	18
Fuel Oil	MJ / litre	38.2
Electricity	MJ / kWh	3.6

Table A.12 – Acronyms

Acronym	Description
GHG	Greenhouse Gas
CO2	Carbon Dioxide
kg CO2eq.	total GHG emissions equivalence to CO2
LDGV	Light-duty gasoline vehicles
LDGT1	Light-duty gasoline trucks under 2722 kg (6000 lb) GVW.
LDGT2	Light-duty gasoline trucks, 2722 kg to 3856 kg (8500 lb) GVW.
HDGV	Heavy-duty gasoline trucks over 3856 kg GVW.
MC	Motorcycles
LDDV	Light-duty diesel vehicles
LDDT	Light-duty diesel trucks under 3856 kg GVW.
HDDV	Heavy-duty diesel trucks over 3856 kg GVW.

Table A.13 – Full Service Vehicle Costs

Cost category	1996	2000	2010	Assumptions / Sources
Fuel	\$ 2,084,620	\$ 2,716,142	\$ 4,291,938	Refer to Table A6
Insurance	\$ 1,647,030	\$ 1,969,740	\$ 3,112,503	Based on average insurance costs in BC per vehicle (\$930) [Litman]
Maintenance & tires	\$ 1,394,663	\$ 1,667,925	\$ 2,635,587	assumes \$0.045 per km [CAA]
Capital Depreciation	\$ 6,978,696	\$ 8,346,064	\$ 13,188,110	\$3940.54 per year, assumes \$21,555 Chevrolet Cavalier less than 4 years old driven 18,000 km per year [CAA]
License, registration and taxes	\$ 226,493	\$ 270,871	\$ 428,019	Canadian average \$127.89 per year [CAA]
Loan Interest	\$ 1,283,975	\$ 1,535,550	\$ 2,426,414	\$725 per year, assumes \$21,555 Chevrolet Cavalier less than 4 years old, 20% down, 7% interest, 4 year loan [CAA]
Total vehicle costs	\$ 13,615,477	\$ 16,506,292	\$ 26,082,571	
Total cost per vehicle	\$ 7,688	\$ 7,793	\$ 7,793	

11 Appendix B – Report for FCM Partners for Climate Protection

This report can be submitted to the FCM Partners for Climate Protection for completion of Milestone One.

Table B.1 – Greenhouse Gas Baseline for Partners for Climate Protection Program

	1996 tonnes CO2 eq	2000 tonnes CO2 eq	2010 tonnes CO2 eq	1996 % of total	2000 % of total	2010 % of total
Residential						
Fuel Oil	680	750	960	19%	14%	11%
Electricity	350	1,200	2,700	10%	23%	31%
Commercial / Municipal / Institutional						
Fuel Oil	140	150	200	4.0%	2.9%	2.2%
Electricity	52	170	380	1.5%	3%	4%
Transportation						
Private Vehicles	2,100	2,700	4,300	59%	52%	48%
Landfills						
Port Mann	68	74	96	1.9%	1.4%	1.1%
Cache Creek	150	170	220	4.4%	3.2%	2.4%
Total	3,500	5,200	8,900			
% increase from 1996		48%	150%			
Annual Growth Rate		10%	6.8%			

12 Appendix C – Baseline Presentation Slides
