Regional District of Nanaimo
Benefits of Green Buildings in the RDN

Final Report

Prepared for:

Regional District of Nanaimo

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July 2008

SUMMARY

Introduction

The construction of high performance green homes and buildings supports efforts to mitigate the environmental impact of the built environment, while reducing the lifecycle costs of buildings and infrastructure.

Compact development patterns and a balanced mix of housing types further reduce the environmental impact of the built environment. Urban containment limits the area of land converted to use for housing and encourages transportation alternatives to the private automobile. A balanced mix of housing types increases the proportion of multi-family dwellings and apartments, leading to greater energy and water efficiency when compared to single family detached dwellings.

The Regional District of Nanaimo has commissioned this analysis to determine the range of environmental impacts and financial implications of promoting green buildings and more sustainable land use patterns in its jurisdiction.

The objectives of this project are to:

- Identify the range of impacts associated with new construction in the RDN over the next 20 years;
- Quantify the annual and cumulative impacts of new construction if it were built to a conventional standard;
- Compare these results to the impacts of the same construction if it were built to an identified standard for green building; and
- Explore the added environmental benefits of green buildings in compact communities.

While this is a quantitative analysis that is heavily reliant on a wide range of calculations, the numbers are derived from a broad set of assumptions based on the best information available. Thus, the critical information lies in the comparisons across scenarios rather than the precise numerical values themselves.

Scenarios

To complete this analysis, three scenarios for new development in the Region were developed, including:

1. Business As Usual Baseline(BAU),
2. Green Buildings (GB), and
3. Green Buildings – Compact Communities (GBCC)

Table S1 provides a summary of assumptions for the three scenarios.

Table S1: Summary of Scenario Assumptions

	Residential	Commercial	Institutional
Business As Usual Scenario			

	Residential	Commercial	Institutional
Energy	EnerGuide 80	ASHRAE 90.1-2004	ASHRAE 90.1-2004
Potable Water	Average use per connection: 0.81 m^3/connection/day Indoor: 77% of consumption Outdoor: 23% of consumption	Varies	
Solid Waste	Disposal: 196 kg/capita/yr (SFD) Diversion rate: 57% (2003)	Disposal: 209 kg/capita/yr Diversion rate: 75%	
Wastewater	84 % of potable water consumed[1]	84 % of potable water consumed	84 % of potable water consumed
Transportation	Not applicable	Not applicable	Not applicable
Green Buildings Scenario			
Standard	EnerGuide 85	LEED Gold (minimum 6 points in Energy & Atmosphere)	LEED Gold (minimum 6 points in Energy & Atmosphere)
Energy	20% reduction	47% reduction	47% reduction
Potable Water	Indoor: 40% reduction Outdoor: 20% reduction	Indoor & Outdoor: 48% reduction	Indoor & Outdoor: 48% reduction
Solid Waste	Disposal: 114 kg/capita/year Diversion rate: 75%	Disposal: 121 kg/capita/year	
Wastewater	84 % of potable water consumed	84 % of potable water consumed	84 % of potable water consumed
Transportation	Not applicable	Not applicable	Not applicable
Green Buildings - Compact Communities Scenario			
Standard	EnerGuide 85	LEED Gold (minimum 6 points in Energy & Atmosphere)	LEED Gold (minimum 6 points in Energy & Atmosphere)
Energy	20% reduction	47% reduction	47% reduction
Potable Water	Indoor: 40% reduction Outdoor: 20% reduction	Indoor: 48% reduction Outdoor: no change	Indoor: 48% reduction Outdoor: no change
Solid Waste	Disposal: 114 kg/capita/year(SFD) Diversion rate: 75%	Disposal: 121 kg/capita/year	
Wastewater	84 % of potable water consumed	84 % of potable water consumed	84 % of potable water consumed
Transportation	Support growth within the urban containment boundary Implement targeted transportation demand management and support public transit		

[1] Based on a review of the literature, it is estimated that approximately 84% of fresh potable water is treated by sewers. However, this estimate varies by location and it is recommended further analysis be completed for the RDN to assess the sewer flows.

Results

Key performance indicators were identified to compare the environmental performance of alternate scenarios, including:

- Building Energy Use,
- Transportation Energy Use,
- Water Consumption,
- Wastewater,
- Solid Waste,
- GHG Emissions, and
- Area of Land Used for Housing.

Financial impacts of the alternative scenarios are presented in terms of:

- Savings in operating expenditures,
- Net present value, and
- Incremental capital cost.

Results of the analysis of new development projected for the Region are presented in Table S2 for the three scenarios:

- The Green Buildings scenario will result in a 40% reduction in water use and a 16% reduction in GHG emissions when compared to business as usual.
- The Green Building – Compact Communities scenario will result in a 48% reduction in water use and a 36% reduction in GHG emissions, as well as a 13% reduction in land area converted to use for housing when compared to business as usual.

Table S2: Environmental Impact of Green scenarios at Build-out (2031)

Environmental Aspect	Business as Usual Scenario	Green Buildings Scenario	Green Buildings - Compact Communities Scenario
Building Energy Use [1000 GJ/year]	5,200	3,700	2,900
Transportation Energy Use [million litres/year]	77	77	54
Water Consumption [1,000 m^3/year]	15,000	8,500	7,800
Waste Water [1,000 m^3/year]	12,600	7,100	6,600
Solid Waste [Tonnes/year]	27,800	16,200	12,500
GHG Emissions [Tonnes/year]	339,000	286,000	218,000
Land Use for Housing [Ha]	2,600	2,600	2,300

A breakdown by resource category and milestone year is presented in Figure S1 to Figure S7. Implementation of a green building strategy will reduce environmental impact of development across all aspects.

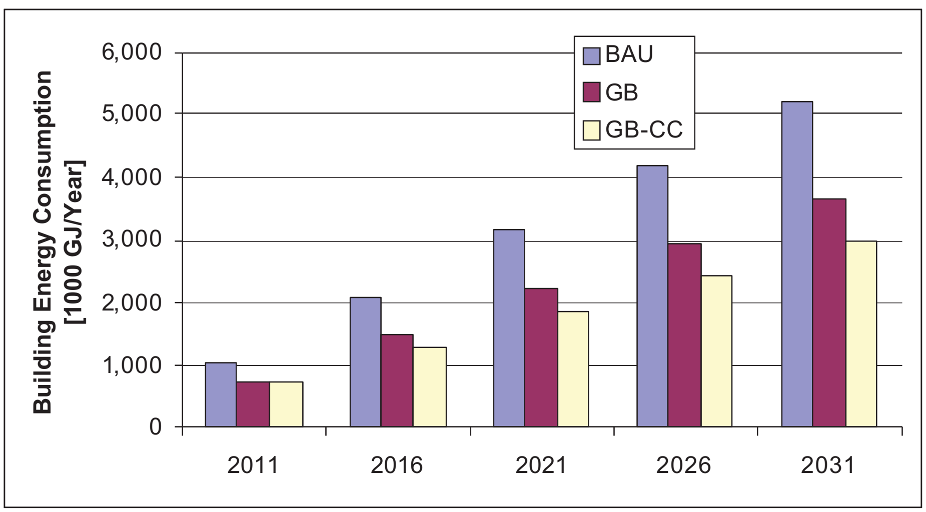


Figure S1: Building Energy Use by Scenario and Milestone Year

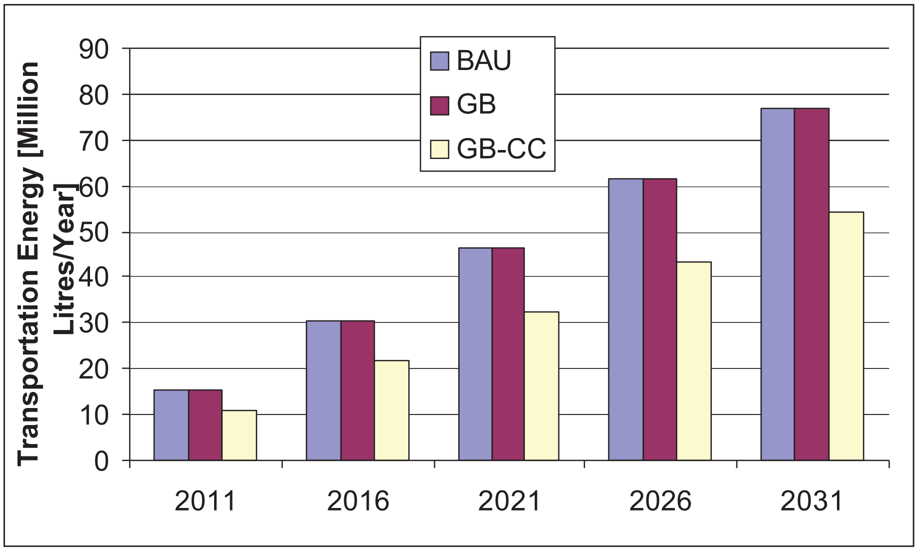


Figure S2: Transportation Energy Use by Scenario and Milestone Year

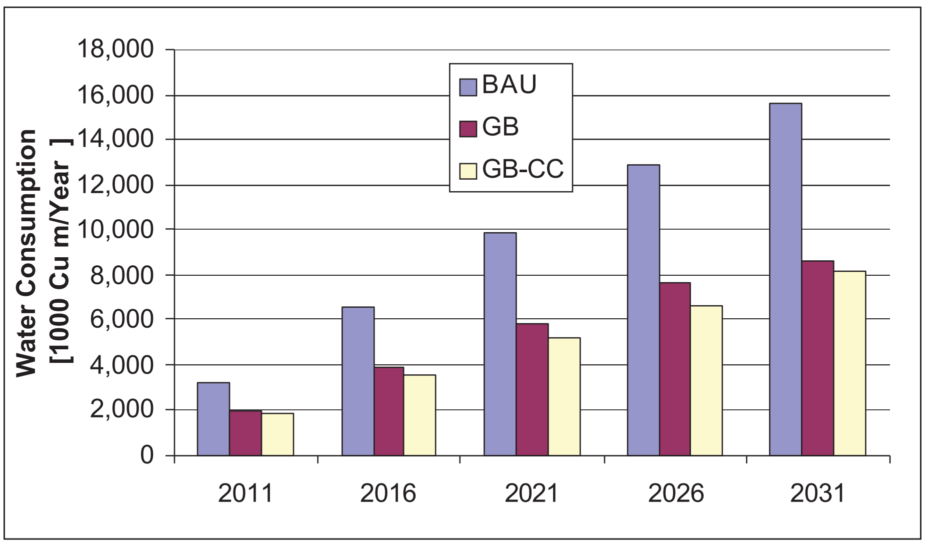
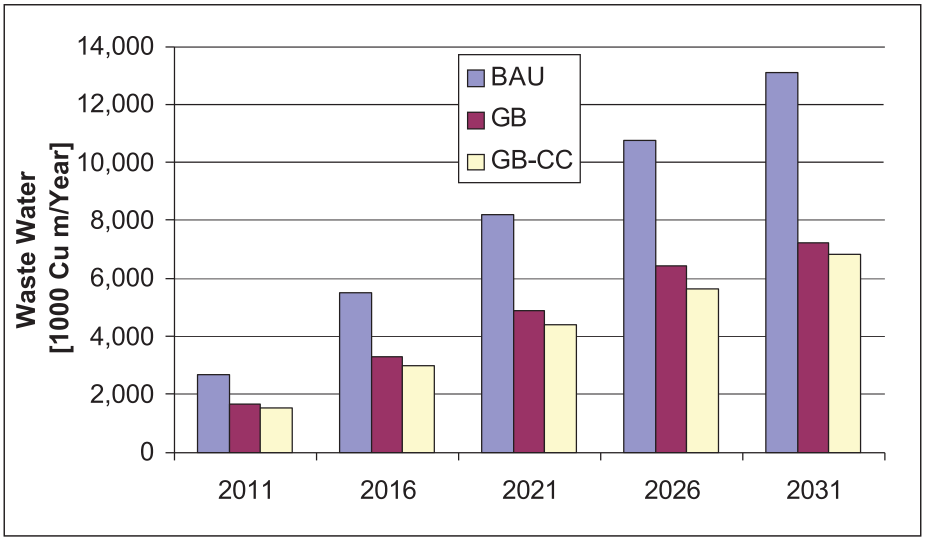


Figure S3: Water Consumption by Scenario and Milestone Year



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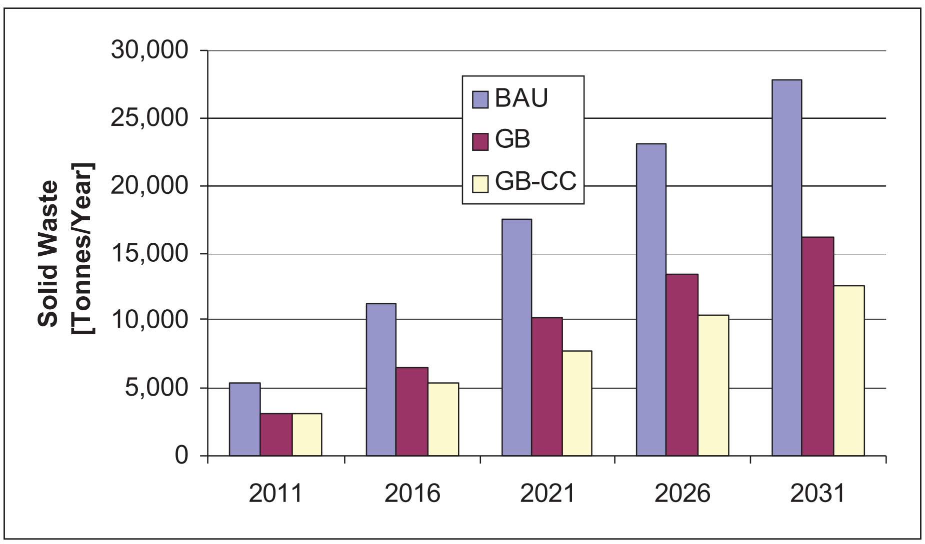

Figure S5: Solid Waste by Scenario and Milestone Year

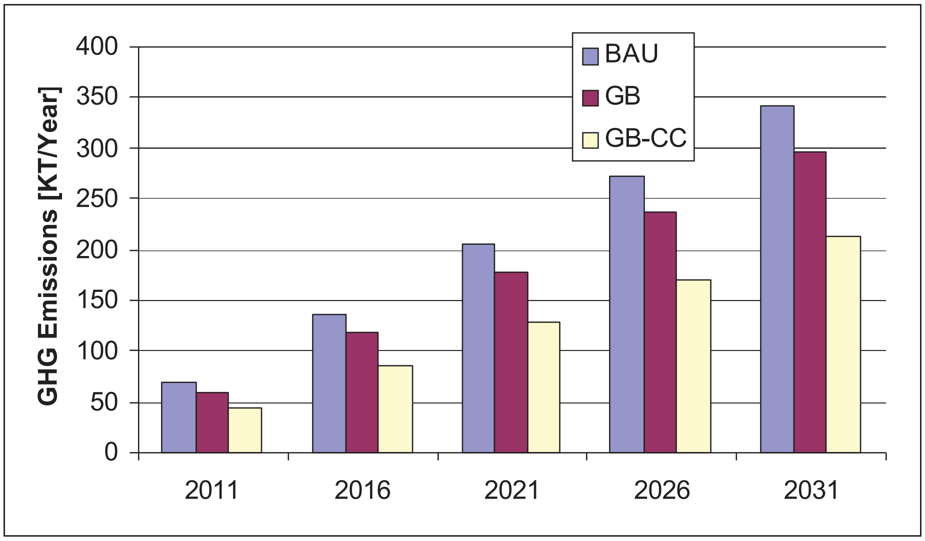

Figure S6 Greenhouse Gas Emissions by Scenario and Milestone Year

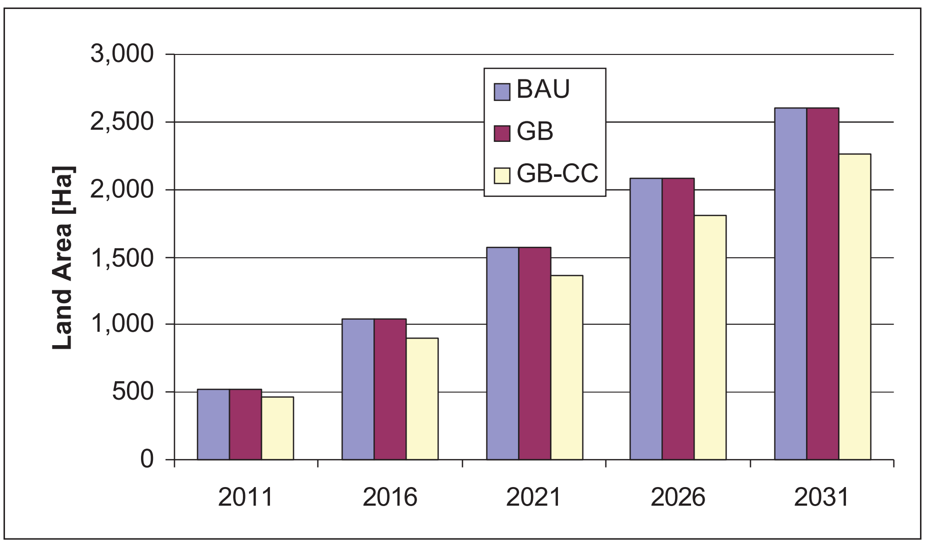

Figure S7: Land Conversion by Scenario and Milestone Year

The financial implications of the green building scenarios are summarised in Table S3. The annual savings in operating expenditures is estimated at $49 million per year and $84 million per year in 2031 for the GB and GB-CC scenarios respectively. To achieve these savings requires an investment of $640 million and $820 million for the GB and GB-CC scenarios respectively. This investment represents the incremental capital cost of construction over the study period from 2011 to 2031. The initial incremental capital cost is offset by lower operating costs over the life of the building, represented by the net present value of $180 million and $590 million for the GB and GB-CC scenarios respectively.

Table S3: Financial Implications of Green Building Scenarios [$ million]

	Green Buildings Scenario	Green Buildings - Compact Communities Scenario
Annual Operating Savings in 2031 (Relative to BAU) [$/Year]	49	84
Incremental Capital Costs (Relative to BAU) [$]	640	820
NPV (@6% discount Rate) (Relative to BAU) [$]	180	590

Conclusions and Recommendations

The environmental and financial benefits of implementing a green building strategy in the RDN are significant. Integration of green buildings with sustainable land use and transportation practices will result in larger benefits than a focus on buildings alone. A market transformation strategy is recommended that utilizes information, education, incentives, pricing and regulation to support program objectives. Policies to support harmonisation of land use, buildings and transportation objectives and activities is within the core mandate of the RDN and member municipalities, and is a prerequisite to achieve the benefits estimated above.

To be successful, it is recommended the program design address a range of capital, knowledge and institutional barriers, as summarised in Table S4. The capital cost barrier is the result of higher costs for building to green standards. Historically, the market has been unwilling to pay these higher costs and the development industry has resisted providing these features for free. It is recommended that this barrier is addressed by developing financial and non-financial incentives. Working with financial service groups to offer financial packages for green building investment is recommended. Industry capacity to deliver buildings with enhanced performance may be addressed through development and delivery of training to local contractors, designers and sales staff. Institutional barriers are broad ranging, and cover issues related to street design for fire protection to concurrent authority clauses between the province and municipalities defining responsibility for the performance requirements in the Building Code. Further analysis is recommended to address barriers and program design options to address them.

Table S4: Barriers for Program Design

Barrier	Examples
Capital	Increased Capital Cost Split Incentives
Knowledge	Industry capacity
Institutional	RDN jurisdictional authority

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1. INTRODUCTION

1.1 Background

The Regional District of Nanaimo (RDN) seeks a quantitative comparison of the environmental and financial impacts from using different green building standards for new construction over a 20 year period. In support of the RDN's Green Building Action Plan, the Benefits of Green Building study identifies opportunities to improve energy efficiency in residential and commercial sectors relative to the British Columbia Building Code (BCBC) and targets set by The BC Energy Plan (BCEP), which include:

- Achieving an EnerGuide for New Houses rating of 80 for 100% of new detached, single family and row houses by 2010;
- Achieving energy performance of 25% better than the Model National Energy Code for 100% of new multi-unit residential buildings by 2010; and
- Achieving energy performance 25% better than the Model National Energy Code for 100% of new commercial and institutional buildings by 2010.

The RDN developed the Green Building Action Plan in 2007 with the goal to "*increase the number of green buildings in the Regional District of Nanaimo*". The plan outlines seven actions to achieve its goal and objectives. This report is in response to item 5a:

> *The RDN will consider commissioning a report to identify the opportunities for green building construction in the RDN. The report will provide information about the amount of new built space anticipated in the region during the next 20 years, and provide information about the impact of this construction if it is constructed to a specific green building standard versus conventional standards.*

In addition to the above, through discussions with RDN staff, the scope of work was expanded to:

- Assess the impact of densification within the RDN on land use, and
- Assess the impact of densification of residential development on transportation.

Shifting from dispersed development patterns to compact urban form will provide significant environmental and financial benefits to the residents and the Regional District, including a reduction of energy consumption, water use and infrastructure costs. Similarly, densification of existing urban areas into nodal and compact development styles will reduce single occupancy travel demand (and increase demand for public transit) and associated environmental and financial costs.

1.2 Project Objectives & Outcomes

The objectives of this project are to:

- Identify the range of impacts associated with new construction in the RDN over the next 20 years[2];
- Quantify the annual and cumulative impacts of new construction if it were built to a conventional standard; and
- Compare these results to the impacts of the same construction if it were built to an identified standard for green building (corresponding to the "Green Buildings scenario".

Additional objectives of the expanded scope of analysis are to:

- Quantify the cumulative impacts of increased density (dwellings per hectare) within the Urban Containment Boundary (UCB) on new green construction;
- Quantify the effects of increased density on transportation (corresponding to the "Green Buildings - Compact Communities scenario"); and
- Compare these results to the Green Buildings scenario.

The final results of this project are intended to advance green buildings, green building practices and compact patterns of development in the Region by providing quantitative information that can be used in the ongoing education of RDN staff and elected officials, and outreach to residents and others. The analysis will also provide a foundation for relevant decision making in the development of policies and partnerships advancing green buildings, green building practices, and compact patterns of development in the Region.

1.3 Scope

This study deals with new residential, commercial and institutional construction. In general, residential buildings are assumed to have a 60 year service life and commercial buildings are assumed to have an 80 year service life.

The study does not include estimates for the industrial or municipal building sectors and only applies to new construction, i.e. it does not include building renovations or retrofits. It is limited to the quantification of impacts related to the operation and maintenance of buildings constructed between 2011 and 2031, as well as transportation impacts associated with new development over that time period.[3]

1.4 Report Structure

The report is separated into the following sections:

Section 2 – Methodology

Section 3 – Scenarios

Section 4 – Results

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[2] Retrofit activity has not been included in this analysis.

[3] The embodied energy of buildings adds an additional 5% – 10% to the lifecycle energy, but depends on a range of factors that are difficult to predict. Therefore, it is not included in the current analysis.

Section 5 – Discussion
Section 6 – Conclusions

References and the details of the assumptions and scenarios are provided at the end of this report in the appendices.

2. METHODOLOGY

2.1 Key Tasks

Two key tasks were undertaken to complete this study. These are:

1. **Define study assumptions**. Study assumptions were outlined in a memo report presented to RDN staff for review and comment. Assumptions from the memo are included in this report; see Appendix A for detailed assumptions. Data sources are documented in References.
2. **Analyse, quantify and compare.** Based on the assumptions outlined in the memo report, an analysis of conventional and green buildings in the residential, commercial and institutional sectors was conducted to quantify the impacts associated with new construction. The results of the impacts of conventionally constructed buildings were compared with the impacts of buildings constructed to green standards.

   An additional scenario was added to assess the impacts of land use and transportation.

2.2 Defining the Impacts

The quantification of impacts in this study is limited to activities related to building operation and maintenance, and transportation. Impacts quantified include:

Building Operation & Maintenance

- Energy consumption,
- Potable water consumption,
- Wastewater generation,
- Solid waste generation,
- GHG Emissions
- Financial impacts associated with the environmental impacts.

Land Use and Transportation

- Population and density
- Urbanised land area
- Passenger vehicle kilometres travelled (VKT),
- Transit vehicle kilometres travelled.

GIS software was used in the Green Buildings - Compact Communities Scenario to determine:

- Population inside and outside the UCB,
- Population density (people per hectare), and
- Number of people living in the UCB within 400 metres of a transit stop.

The methodology for determining the above is outlined in the following sections. These numbers form the basis of assumptions for the Green Buildings - Compact Communities Scenario analysis of the effects of land use and transportation impacts.

Population Within and Without Urban Containment Boundaries

For the purpose of this analysis, the Urban Containment Boundary was used as the geographic area where population would be concentrated in the future. As part of the Regional Growth Strategy process, the municipalities and the electoral areas agreed to designate Urban Containment Boundaries that define urban and rural areas.[4] This is a tool that articulates and supports the first goal of the RGS, which is to have "Strong Urban Containment." Figure 8 shows the size and location of the UCBs that are located in the Regional District of Nanaimo. These boundaries were exported to PCensus, a software application that used the UCBs to calculate current 2006 population within that area.

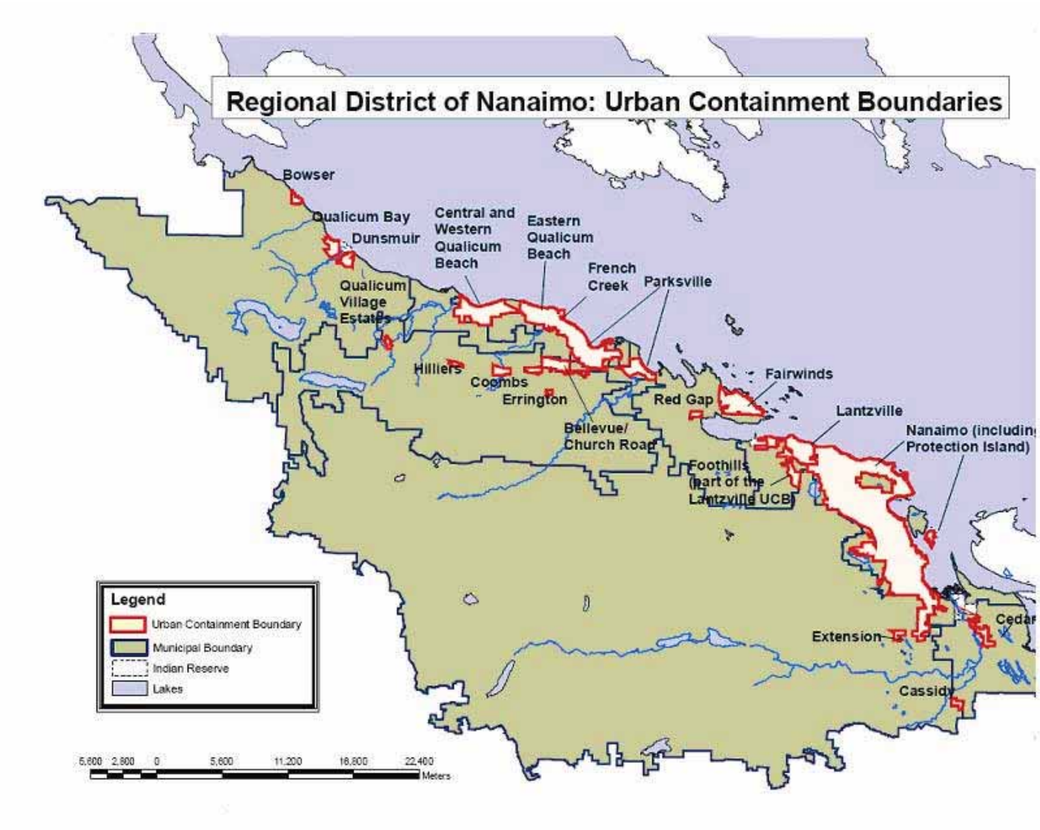

Figure 8: RDN Urban Containment Boundaries

Population Density per Hectare

PCensus was also used to calculate density based on the number of people from the 2006 Census divided by the amount of developable land provided from the *Regional Growth Strategy Background Report: Land Inventory & Residential Capacity Analysis*. Density was calculated inside and outside the Urban Containment Boundaries. Constraints such as slope and riparian

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4 Note: The UCB indicated here is as determined in 2003 and does not include the UCB amendment for expansion as proposed in the City of Nanaimo Official Community Plan.

areas were removed, and roads were netted out to provide a more accurate snapshot of available developable land.

3. SCENARIOS

Three scenarios were developed for this study: Business As Usual (BAU), Green Buildings (GB), and Green Buildings - Compact Communities (GB-CC). Each scenario is described in detail in the following sections.

The time period for this study is 2011 – 2031. The year 2011 was chosen to align with previous population and housing projection studies, and with BC government targets.[5]

3.1 Business As Usual Scenario

The Business As Usual scenario is based on the **minimum** required building standard in 2011 and will be used to determine the impacts of buildings constructed to this standard – this is the baseline. During the study period:

- New houses will be required to meet EnerGuide 80,
- New commercial, institutional and multi-unit residential buildings will be required to meet ASHRAE 90.1-2004, and
- Low flow water fixtures will be required.

Rationale

The business-as-usual assumptions are based on current changes to the BC Building Code and provincial government targets. These are outlined below in detail.

On April 15, 2008 the Minister responsible for Housing, announced changes to the BC Building Code that will increase energy and water efficiency in buildings across BC. These changes will come into effect September 5, 2008 and are:

- EnerGuide for Houses rating of 77 or equivalent insulation standard.
- ASHRAE 90.1-2004 for commercial, institutional and multi-unit residential buildings.
- Ultra low-flow toilets (6 L per flush) and other water-saving plumbing fixtures and fittings will be mandatory in new construction and renovations.

In addition, the BC Energy Efficient Buildings Plan outlines targets for residential, commercial and institutional buildings. These are:

- Residential: an EnerGuide for Houses rating of 80 for all new single detached dwellings and row houses by 2010.
- Commercial and Institutional: energy performance of 25% better than the Model National Energy Code (approximately corresponding to a 10% improvement in performance relative to ASHRAE 90.1-2004) for new commercial, institutional and multi-unit residential buildings by 2010.

[5] Population projection data from Urban Futures Population and Housing Change report is provided every five years, in Census years.

By 2011, it is assumed that all new buildings are constructed to conventional standards, 100% of new residential dwellings in the Regional District of Nanaimo meet the BC Energy Efficient Buildings Plan targets, and 100% of commercial and institutional buildings meet BC Building Code standard.

3.2 Green Buildings Scenario

This scenario calculates the impacts of green construction, assuming all aspects of green buildings are implemented. During the study period, buildings will be constructed to the following standards:

- New residential construction:
  - EnerGuide 85 for energy, and
  - Built Green™ Gold for non-energy related issues.
- Non residential construction
  - LEED® Gold using points awarded as basis for performance improvements.

Rationale

Constructing a residential dwelling to meet EnerGuide 85 is currently possible with existing technology although with an estimated $17,300 increase in the capital cost of the unit. Modeling was completed to assess the performance improvement of a typical new single-family dwelling. Results are summarised below (Table 5) for a range of performance levels.

Table 5: Summary of Performance Costs, Benefits and Paybacks for Different Housing Performance Levels

	Energy Use (kWh/yr)	Savings[6]		Incremental Capital Cost	Payback (Years)
		Percentage	$/yr		
Base Building	26,800	0%	$0		
EGH 80	19,300	28%	$450	$4,700	10
EGH 85	14,000	48%	$768	$17,300	23
EGH 90	8,000	70%	$1,128	$29,700	26
Low Energy	3,000	89%	$1,428	$58,700	41
Zero Energy	0	100%	$1,608		

Incremental capital costs for semi-detached dwellings and apartments are estimated at $12,500 and $3,600, respectively. For commercial and institutional buildings constructed to LEED® Gold, the incremental capital cost is estimated at approximately 9% on a construction budget of $2,000/sq m, which amounts to about $180/sq m[7].

[6] Payback period is entirely dependent on energy cost. This analysis assumes a constant cost of energy. If energy costs rise, the payback period shortens.

[7] Altus Group, January 2008. LEED® Overview.

Built Green™ and LEED® are quickly becoming a mainstream practice in the building industry. It is expected that by 2011, there will be capacity in the construction industry to build the majority of residential, commercial and institutional units to these standards.

Built Green™[8] is a voluntary green rating system for residential dwellings, not including multi-family units, based on a points system. Built Green™ Gold requires a minimum EnerGuide rating of 77 and 100 points from the checklist. In this scenario, it is assumed that residential dwelling units meet an EnerGuide rating of 85 while the remaining systems achieve the minimum requirements for the Gold standard.

LEED® is a well recognized points-based rating system for multi-family, commercial and institutional buildings with four levels of achievement (Certified, Silver, Gold and Platinum). Constructing a building to meet the LEED® Gold certification level results in significant reductions in energy and water use and reduces construction waste. The Gold level is achievable and demonstrates leadership by the RDN. Many municipalities and organizations have developed policies that state all new buildings will be constructed to the LEED® Gold standard. As of May 9, 2008, almost 40% of LEED® certified buildings in Canada met the Gold level criteria.

3.3 Green Buildings - Compact Communities Scenario: Sustainable Land Use and Transportation

This scenario calculates the impacts of dramatically increasing residential density within the urban containment boundary (UCB) and examines the transportation impacts from this increased density. There are two key reasons for exploring this scenario. Firstly, regulating land use, including the location and density of development, is within the authority of Local Governments, and is a key mechanism by which Local Governments can influence community sustainability. In particular, compact land use enhances the viability of transit and reduces reliance on the private automobile while the diversity of housing types in compact communities increases the proportion of energy and water efficient multi-unit dwellings such as townhomes and apartments while also meeting the needs of a wide range of residents.

Secondly, the Province of British Columbia has set the ambitious target of reducing BCs greenhouse gas emissions by at least 33 percent below current levels by 2020 and green building alone will not reach this target. Therefore, an equally ambitious approach to land use is considered for this analysis in order to get as close as possible to a 33 percent reduction in greenhouse gas emissions during the study period:

- New residential construction will achieve:
    - EnerGuide 85 for energy, and
    - Built Green™ Gold for non-energy related issues.
- Non-residential (commercial and institutional) impacts will be the same as in the Green Buildings Scenario.

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[8] More information on the Built Green™ rating system can be found here: www.builtgreencanada.ca/content.php?id=262

- After 2011, all new development occurs within the UCB, as per Goal 1: Strong Urban Containment, Policy 1B of the Regional Growth Strategy. No additional dwellings are constructed outside the UCB post-2011. The increase in population and associated new development is accommodated within the UCB.
- Within the UCB:
  - No new single family dwellings will be constructed after 2011.
  - Of the existing single family dwelling stock, 30% will be redeveloped into higher density housing forms, such as Other Ground Oriented and Apartments.
  - By 2031, 83% of the population resides here, representing a shift of 25% from those living outside the UCB (in 2006, 67% of the population resided within the UCB).
- The calculation of density (dwelling units or population) is an average for the designated UCB area. It is not specific to individual municipalities or electoral areas but is meant to provide a high level estimate of the impacts of increasing dwelling and population density within the UCB.
- Transportation impacts are limited to the UCB as currently there is limited public transportation service for areas outside the UCB except along major transportation corridors.

Rationale

Urban Densification

The Regional Growth Strategy adopted in June 2003 defines strong urban containment as a goal. As such, it is expected that future housing and population density will increase within the UCB. Currently, there are 4.8 dwellings per hectare or approximately 10.5 people per hectare within the region's UCB. Tripling the density to 15 dwelling units per hectare[9] or 27 people per hectare in urban areas would still be considered low density by planning standards. Note that as dwelling and population density increases, the average household size decreases[10].

Land use can affect travel behaviour and modes of travel. The report "Use Impacts on Transport: How Land Use Factors Affect Travel Behavior" notes that in one case, "transit ridership increases with local land use density"[11] and that neighbourhood density has a greater effect on transit ridership than household income. Increasing housing and population density within the UCB can have positive effects on energy consumption and transportation use and their associated impacts. Personal income, land availability and price, and an aging population will also drive development within the UCB. However, if energy prices remain high, the costs associated with living in suburban single family dwellings may further drive urban development and increased densification.

[9] Calculated based on the total developable area inside the UCB of urban areas. Note that the density would be approximately 13 units per hectare if calculated based on the total developable area inside the UCB.

[10] The Sheltair Group, October 2007. Land Inventory and Residential Capacity Analysis.

[11] Litman, 2008. Page 11.

Transportation

Currently, about 3% of the working population in the RDN uses transit to commute to work. The majority of residents commute to work as a driver of a vehicle (80%) or as a passenger (7%), even though 75% of residents living within the UCB are within 400 metres of a transit stop. While the mode share is not known for trip purposes other than commuting, it can be assumed that the majority of trips use passenger vehicles. The high use of passenger vehicles is likely due to a number of factors such as low density development, inconvenient transit (i.e. it takes the same amount of time to drive as it does to take the bus), work place in another town centre, and relatively inexpensive vehicle operating costs (e.g. fuel and maintenance).

With a combination of transportation demand management (TDM) strategies and land use policies, vehicle use will decline and transit and other modes of transportation will increase. This study attempts to provide a high-level estimate of the effects of increased density within the UCB and basic TDM strategies.

3.4 Summary of Assumptions

The following table provides a summary of assumptions for the three scenarios. The details of the assumptions may be found in Appendix A.

Table 6: Summary of Scenario Assumptions

	Residential	Commercial	Institutional
Business As Usual (2011)			
Energy	EnerGuide 80	ASHRAE 90.1-2004	ASHRAE 90.1-2004
Potable Water	Average use per connection: 0.81 m^3/connection/day Indoor: 77% of consumption Outdoor: 23% of consumption	Varies	
Solid Waste	Disposal: 196 kg/capita/yr (SFD) Diversion rate: 57% (2003)	Disposal: 209 kg/capita/yr Diversion rate: 75%	
Wastewater	84 % of potable water consumed[12]	84 % of potable water consumed	84 % of potable water consumed
Transportation	Not applicable	Not applicable	Not applicable
Green Buildings			
Standard	EnerGuide 85	LEED Gold (minimum 6 points in Energy & Atmosphere)	LEED Gold (minimum 6 points in Energy & Atmosphere)
Energy	20% reduction	47% reduction	47% reduction
Potable Water	Indoor: 40% reduction Outdoor: 20% reduction	Indoor & Outdoor: 48% reduction	Indoor & Outdoor: 48% reduction
Solid Waste	Disposal: 114 kg/capita/year Diversion rate: 75%	Disposal: 121 kg/capita/year	
Wastewater	84 % of potable water consumed	84 % of potable water consumed	84 % of potable water consumed
Transportation	Not applicable	Not applicable	Not applicable
Green Buildings - Compact Communities			
Standard	EnerGuide 85	LEED Gold (minimum 6 points in Energy & Atmosphere)	LEED Gold (minimum 6 points in Energy & Atmosphere)
Energy	20% reduction	47% reduction	47% reduction
Potable Water	Indoor: 40% reduction Outdoor: 20% reduction	Indoor: 48% reduction Outdoor: no change	Indoor: 48% reduction Outdoor: no change
Solid Waste	Disposal: 114 kg/capita/year(SFD) Diversion rate: 75%	Disposal: 121 kg/capita/year	
Wastewater	84 % of potable water consumed	84 % of potable water consumed	84 % of potable water consumed
Transportation	Support growth within the urban containment boundary Implement targeted transportation demand management and support public transit		

[12] Based on a review of the literature, it is estimated that approximately 84% of fresh potable water is treated by sewers. However, this estimate varies by location and it is recommended further analysis be completed for the RDN to assess the sewer flows.

4. RESULTS

4.1 Introduction

This section provides an estimate of the impacts of development in the RDN, including environmental and financial impacts. Results of the business as usual, Green Buildings and Green Buildings - Compact Communities scenarios are presented. A summary and comparison of the impacts is presented. Detailed calculations and results are presented in Appendix B.

To quantify the environmental impacts of alternative scenarios, key performance indicators have been applied, including:

- Building energy
- Personal transportation energy
- Water consumption
- Waste water
- Solid waste
- GHG emissions
- Land Use for housing

Financial impacts of the alternative scenarios are presented in terms of

- Savings in operating expenditures
- Net present value
- Incremental capital cost

Additional indicators are presented in Appendix B.

4.2 Business as Usual Scenario

The environmental impact of new development in the RDN in 2031 is summarised in Table 7 in terms of key performance indicators. As can be seen, the business as usual development will result in significant impact, including 339 KT/year of additional GHG emissions relative to current consumption.

Table 7: Environmental Impact of Development in 2031 (Business As Usual Scenario)

Environmental Aspect	BAU Scenario
Building Energy [1000 GJ/year]	5,200
Passenger Transportation Energy [million litres/year]	77.0
Water Consumption [1,000 m^3/year]	15,000
Waste Water [1,000 m^3/year]	12,600
Solid Waste [Tonnes/year]	27,800
GHG Emissions [Tonnes/year]	339,000
Land Use for Housing [Ha]	2,600

Operating costs for energy, water and waste services is estimated at $226 million/year in 2031. A breakdown by resource and Milestone year is presented in Table 8.

Table 8: Annual Operating Cost of Business as Usual Scenario by Milestone Year [$million/Year]

	2011	2016	2021	2026	2031
Building Energy	$23	$46	$69	$92	$113
Transportation Energy	$18	$37	$55	$74	$92
Water/Waste Water	$4	$8	$12	$17	$19
Solid Waste	$0.4	$1	$1	$2	$2
Total Operating Costs	$45	$92	$138	$184	$226

4.3 Green Buildings Scenario

Results of the Green Buildings scenario are presented in Table 9. As can be seen, adopting the Green Buildings scenario will result in a considerable improvement in environmental performance for the RDN, including a 43% reduction in water use and a 16% reduction in GHG emissions.

Table 9: Environmental Impact of Development in 2031 (Green Buildings Scenario)

Environmental Aspect	Business As Usual Scenario	Green Buildings Scenario	% Improvement (Relative to BAU)
Building Energy Use [1000 GJ/year]	5,200	3,700	29%
Transportation Energy Use [million litres/year]	77.0	77.0	0%
Water Consumption [1,000 m^3/year]	15,000	8,500	43%
Waste Water [1,000 m^3/year]	12,600	7,100	44%
Solid Waste [Tonnes/year]	27,800	16,200	42%
GHG Emissions [Tonnes/year]	339,000	286,000	16%
Land Use for housing [Ha]	2,600	2,600	0%

Analysis of the financial implications of the Green Buildings scenario was completed, and results summarised in Table 10. The analysis indicates that residential, commercial and institutional buildings constructed to green standards would result in annual savings of operating expenditures of $49 million/year at build-out in 2031, and a net present value of $180 million. The incremental capital cost of building to green standards between 2011 and 2031 is $640 million.

Table 10: Annual Operating Cost of Green Buildings Scenario by Milestone Year [$ million/Year]

	2011	2016	2021	2026	2031
Building Energy	$14	$29	$44	$59	$73
Transportation Energy	$18	$37	$55	$74	$92
Water/Waste Water	$2	$5	$7	$10	$11
Solid Waste	$0.2	$0.5	$1	$1	$1
Total Operating Costs	$35	$71	$107	$143	$177

The breakdown of annual savings by resource category is presented in Table 10 assuming:

- Constant prices for energy, water and solid waste costs,
- 100% implementation in new construction,
- Maintenance and repair costs are not included as they are assumed to be the same across all scenarios (see Appendix A for further details).

Comparing Table 8 and Table 10, the most significant financial opportunity is related to savings in energy expenditures. As noted above, the cost of energy is assumed constant. However, if energy prices continue to increase, these estimates understate the financial benefits of adopting the green building strategy.

4.4 Green Buildings - Compact Communities Scenario

The impact of adopting green buildings strategies in conjunction with integrated land use and transportation measures is summarised in Table 11. As can be seen, there is significant additional impact relative to the Green Buildings scenario. In summary, the Green Buildings - Compact Communities scenario will result in a 36% reduction in GHG emissions and a 13% reduction in land conversions.[13] As can be seen, an integrated approach to support green buildings and compact complete development patterns will reduce resource consumption in all environmental performance aspects.

Table 11: Environmental Impact of Development in 2031 (Green Buildings - Compact Communities Scenario)

Environmental Aspect	Business As Usual Scenario	Green Buildings - Compact Communities Scenario	% Improvement (Relative to BAU)
Building Energy Use [1000 GJ/year]	5,200	2,900	48%
Transportation Energy Use [million litres/year]	77.0	54	30%
Water Consumption [1,000 m^3/year]	15,000	7,800	48%
Waste Water [1,000 m^3/year]	12,600	6,600	48%
Solid Waste [Tonnes/year]	27,800	12,500	55%
GHG Emissions [Tonnes/year]	339,000	218,000	36%
Land Use for Housing [Ha]	2,600	2,300	13%

Analysis of the financial implications of the Green Buildings - Compact Communities scenario is summarised in Table 12. The results of the analysis indicate that residential, commercial and institutional buildings constructed to green standards would result in annual reduction of operating expenditures of $84 million/year at build-out in 2031, and a net present value of $580 million. The incremental capital cost of building to green standards between 2011 and 2031 is $817 million.

[13] Even with significant densification, the Provincial goal of reducing emissions by 33% below current levels by 2020 is missed, demonstrating the need to couple green building and compact development with major investment in renewable energy and a strong commitment to protecting the carbon storage related services provided by healthy, well functioning ecosystems.

Table 12: Annual Operating Cost of Green Buildings – Compact Communities Scenario by Milestone Year [$million/Year]

	2011	2016	2021	2026	2031
Building Energy	$16	$29	$43	$56	$66
Transportation Energy	$13	$26	$39	$52	$65
Water/Waste Water	$2	$5	$8	$11	$10
Solid Waste	$0.2	$0.4	$1	$1	$1
Operating Cost	$31	$61	$90	$120	$142

In addition to the benefits outlined above, there are a range of infrastructure benefits from promoting compact development within urban containment boundaries that are not amenable to the current high level analysis. Further, the current analysis does not include land costs, and with policy to encourage densification, these changes to costs could be significant.

4.5 Summary

A summary of the environmental benefits of the Green Buildings and Green Buildings – Compact Communities scenarios is presented in Table 13 and Figure 9 to Figure 15. There is significant opportunity to reduce the footprint of development across all environmental aspects. In particular,

- The Green Buildings scenario will result in a 40% reduction in water use and a 16% reduction in GHG emissions when compared to business as usual.
- The Green Building – Compact Communities scenario will result in a 48% reduction in water use and a 36% reduction in GHG emissions, as well as a 13% reduction in land area converted to use for housing when compared to business as usual.

Table 13: Summary of Environmental Impact of Green Scenarios at Build-out (2031)

Environmental Aspect	Business as Usual Scenario	Green Buildings Scenario	Green Buildings – Compact Communities Scenario
Building Energy Use [1000 GJ/year]	5,200	3,700	2,900
Transportation Energy Use [million litres/year]	77	77	54
Water Consumption [1,000 m^3/year]	15,000	8,500	8,100
Waste Water [1,000 m^3/year]	12,600	7,100	6,800
Solid Waste [Tonnes/year]	27,800	16,200	12,500
GHG Emissions [Tonnes/year]	339,000	294,000	218,000
Land Use for Housing [Ha]	2,600	2,600	2,300

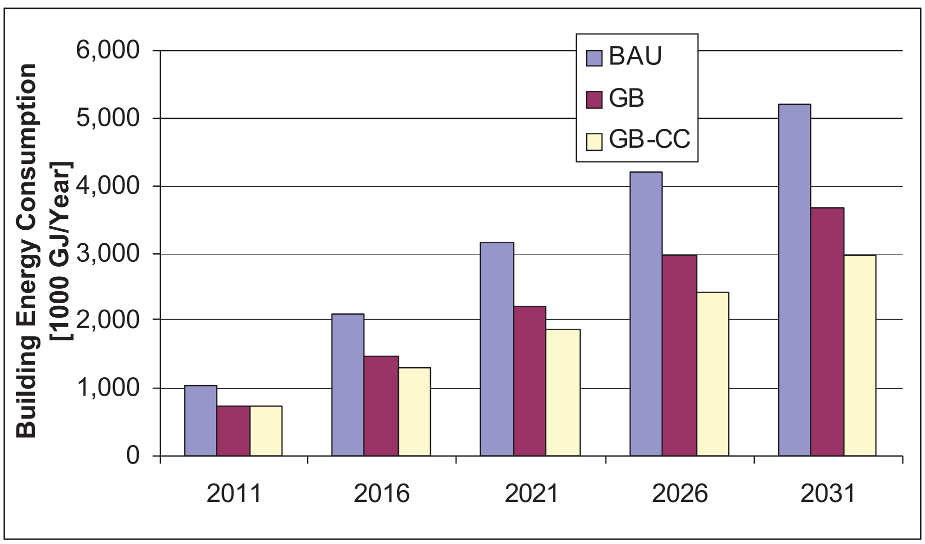

Figure 9: Building Energy Use by Scenario and Milestone Year

Savings in energy use from buildings are achieved from improvements in energy efficiency of construction, as well as through a shift to more apartments and row style homes, which use less energy for space heating than single family homes.

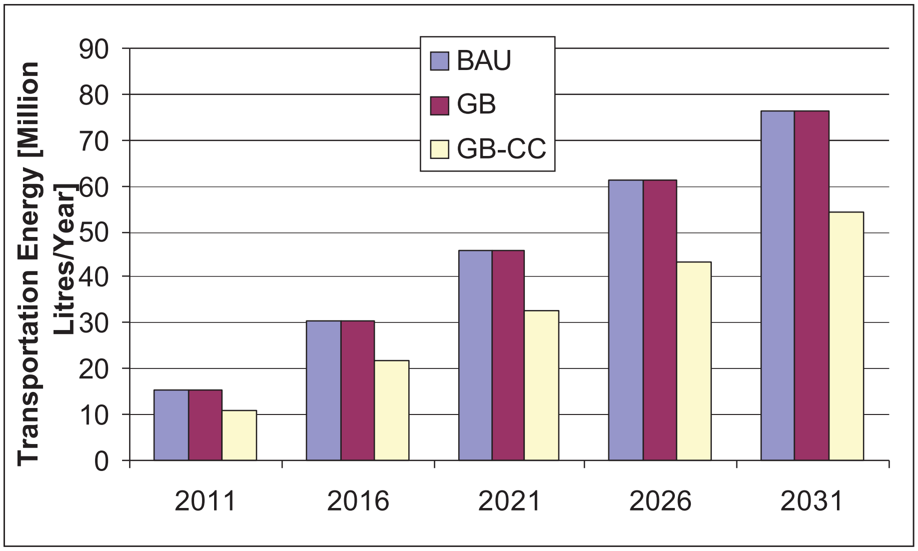

Figure 10: Transportation Energy Use by Scenario and Milestone Year

Transportation energy is measured in litres of fuel consumed and is based on an estimate of vehicle kilometres travelled for each scenario. Land use in the GB scenario mirrors the BAU scenario, so transportation energy is the same in both with 15 million litres of fuel consumed in 2011 rising to 77 million litres of fuel consumed in 2031. By contrast, reduced transportation demand associated with compact community design results in significant fuel savings in the GB-CC scenario, with 54 million litres of fuel consumed in 2031.

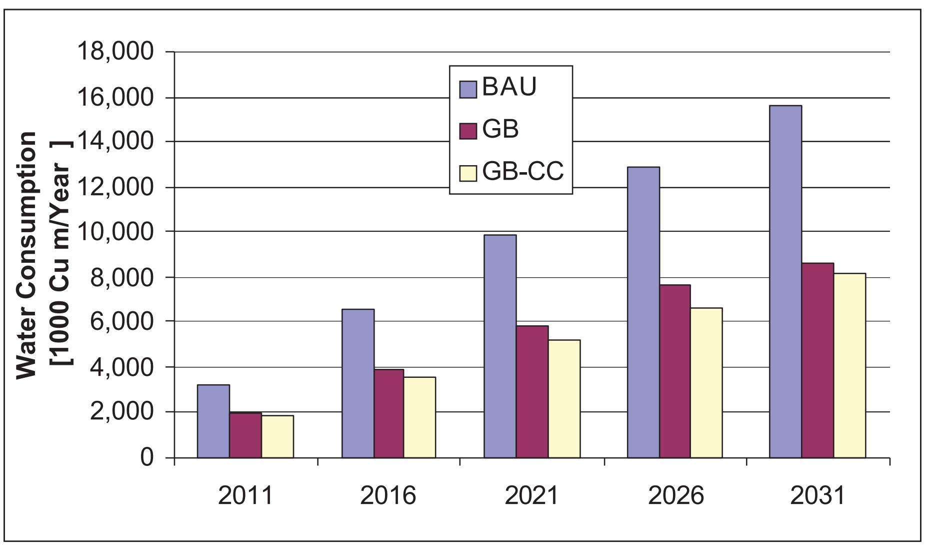

Figure 11: Water Consumption by Scenario and Milestone Year

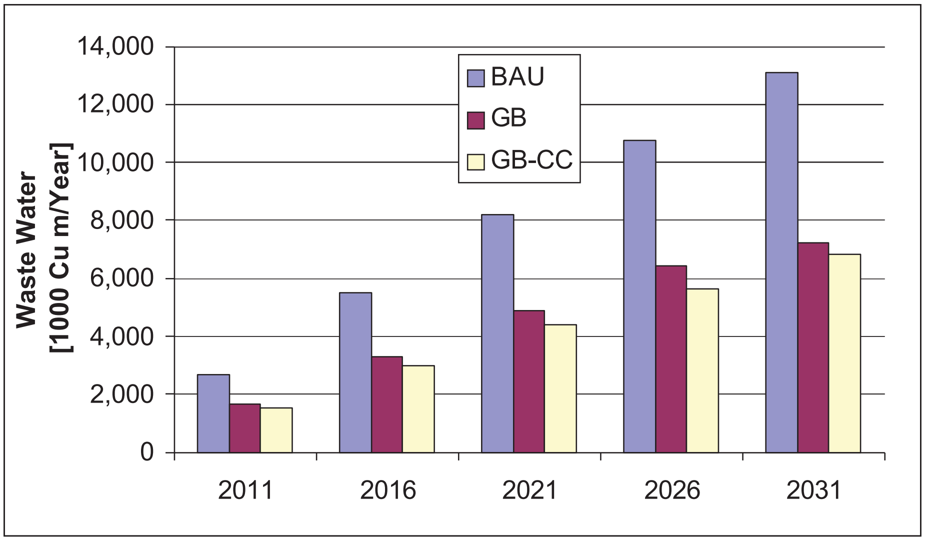

Figure 12: Waste Water Generation by Scenario and Milestone Year

Savings in water are achieved through water conserving fixtures. In addition, the shift in housing types assumed in the GB-CC scenario leads to further savings in water and waste water. As noted previously, waste water is calculated based on water consumption, and is estimated at 84% of total water consumption.

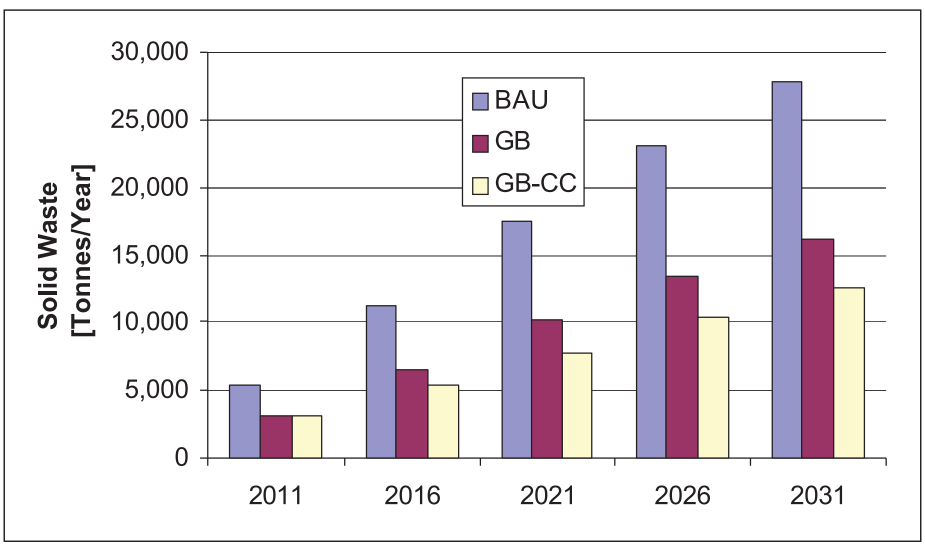

Figure 13: Solid Waste by Scenario and Milestone Year

Reduction in solid waste is achieved through lower outdoor yard waste as well as increased diversion potential from implementation of solid waste credits in relevant green building guidelines.

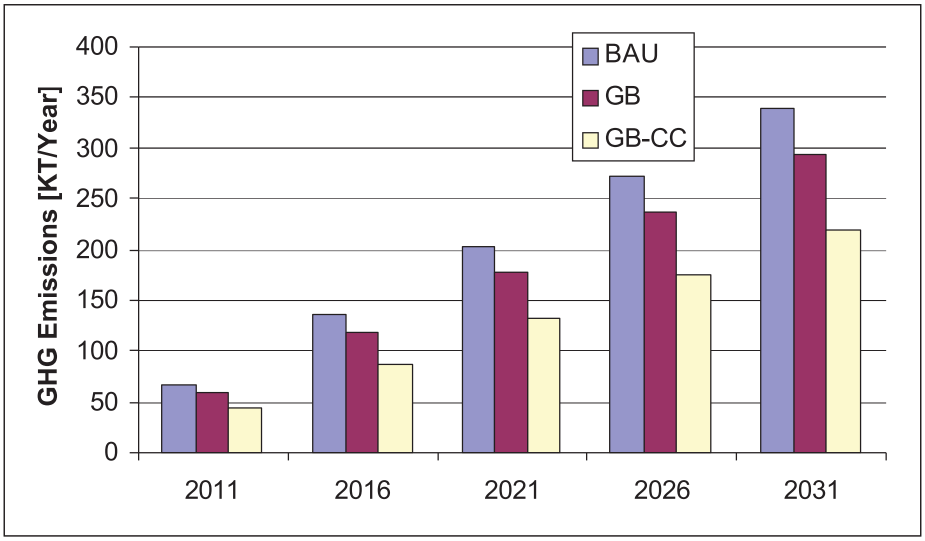

Figure 14: Greenhouse Gas Emissions by Scenario and Milestone Year

The GHG emissions estimate includes impacts from buildings, solid waste and transportation.

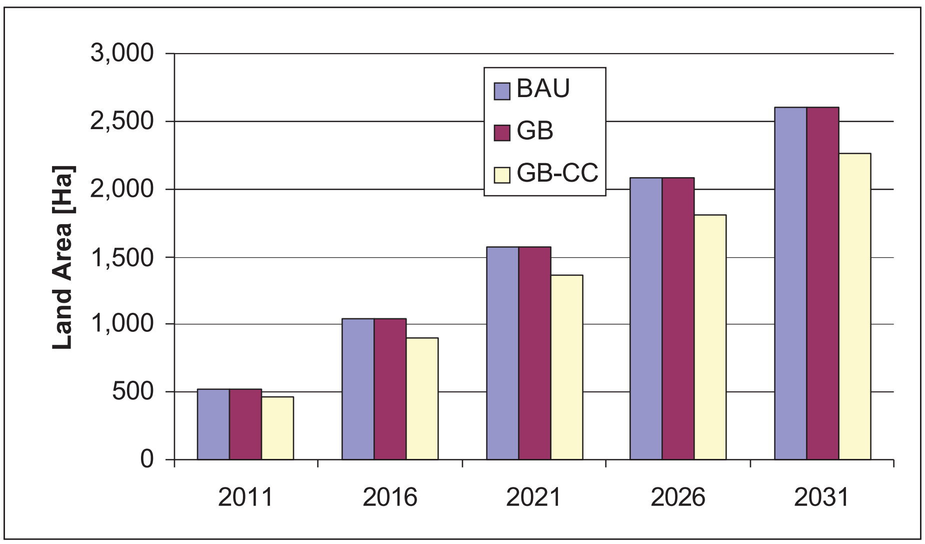

Figure 15: Land Conversion by Scenario and Milestone Year

As stated above, the land use pattern for the BAU and GB scenarios is the same. For these scenarios, 2,600 hectares of land is converted to use for housing by 2031, as shown in Figure 15. By concentrating development in Urban Containment Boundaries, the GB-CC scenario projects that 2,300 hectares, or 12% less land is converted to use for housing over the same time period.

The impact on operating costs of the green building scenarios are summarised in Table 14. The savings from implementation of the GB and GB-CC scenarios is estimated at $49 million and $84 million/year in 2031, relative to the business as usual scenario.

Table 14: Savings in Operating Costs from Green Building Scenarios [$million/year] by Scenario and Milestone Year

	2011	2016	2021	2026	2031
Business as Usual Scenario	$45	$92	$138	$184	$226
Green Buildings Scenario	$35	$71	$107	$143	$177
Green Buildings – Compact Communities Scenario	$31	$61	$90	$120	$142
Savings (BAU to GB)	*$10*	*$20*	*$31*	*$41*	*$49*
Savings (BAU to GBCC)	*$14*	*$31*	*$48*	*$64*	*$84*

The incremental capital cost and net present value of the green building scenarios is summarised in Table 15. To achieve the operating savings requires an investment of $640 million and $820 million for the GB and GB-CC scenarios respectively. This investment represents the incremental capital cost of construction over the study period from 2011 to 2031. The initial incremental capital cost is offset by lower operating costs over the life of the building, represented by the net present value of $180 million and $590 million for the GB and GB-CC scenarios respectively.

Table 15: Financial Implications of Green Building Scenarios at Build-out (2031) [$ million]

	Green Buildings Scenario	Green Buildings - Compact Communities Scenario
Incremental Capital Costs (Relative to BAU)	$640	$820
NPV (@6% discount Rate) (Relative to BAU)	$180	$590

5. DISCUSSION

5.1 Energy as a Driver

As can be seen from this analysis, energy savings is a key financial and environmental driver in promoting the green building and land use scenarios. While energy prices are cyclical, there is recognition that recent price increases are the result of demand growth in less developed countries. In contrast, previous price spikes have been driven by political means in oil producing regions. As a result of this structural shift in the world economies, the current prices for energy may be sustained, meaning the current analysis estimates of the benefits of the green building scenarios may be conservative.

5.2 Intangible Benefits of Green Buildings

In addition to the direct environmental and financial benefits of promoting a green building strategy in the RDN, a range of additional intangible benefits accrue to a range of stakeholders, as summarised in Figure 16. In promoting green buildings, it is frequently the intangible benefits such as occupant comfort or reduced absenteeism that may be the decisive factor. It is recommended that these additional benefits be highlighted as part of any green building strategy in the RDN.

	Occupant	Neighbour	Owner	Developer	Designer	Investor/ Lender	Municipal Gov.	Provincial Gov.	Federal Gov
Economic	High	No	Medium	Medium	Medium	Medium	Medium	No	No
Occupant Health	High	No	Medium	No	No	Medium	Medium	Medium	Medium
Risk Reduction	Low	No	High	Medium	Medium	Medium	No	No	Medium
Climate Change	No	No	No	No	No	No	Medium	Medium	Medium
Ecological	No	Medium	Medium	No	No	Medium	Medium	Medium	Medium
Decreased Infrastructure	No	No	Medium	Medium	No	Medium	High	Medium	Medium
Occupant Comfort	High	No	Medium	Medium	No	Medium	No	Medium	No

Legend:

No Impact	(white)
Low Impact	(light grey)
Medium Impact	(medium grey)
High Impact	(dark grey)

Figure 16: Green Building Stakeholders and Benefits

5.3 Land Use Impacts

The current analysis examines the potential benefits of promoting growth within the urban containment boundary, which results in considerable reduction in travel demand and building energy use. Further analysis is recommended to understand the energy savings opportunities of alternative land use strategies. This will require a more detailed and spatial analysis. For example, public transit is most cost effective when the urban density exceeds 25 units per hectare. Further analysis will reveal how best to achieve such thresholds. Similarly, district energy systems are increasingly seen as a key opportunity to reduce energy consumption and GHG emissions in communities, though these systems generally require higher density, mixed use development.

5.4 Financing Green Buildings

As noted previously, the financial payoffs of green buildings in terms of reduced operating costs exceed the incremental capital cost. In general, developers are unwilling to invest capital in projects if that investment does not result in increased sales prices. Successful implementation of a green building strategy will require program components to ensure that developers and building landlords are not subsidising lower operating costs for occupants and tenants. This has historically been called the split incentive problem associated with green buildings, and working with financial institutions to overcome this barrier will be central to a successful program. In particular, there are a number of institutions that are starting to recognise the higher retail and assessment value of green buildings.

5.5 Industry Capacity

The construction industry is one of the most fragmented segments of the economy, resulting in slow innovation uptake and boom-bust cycles that make it difficult to ensure energy efficient buildings can be constructed consistently, reliably and durably. While promoting environmental performance is the key objective, achieving that outcome will require considerable investment in training and capacity development.

5.6 Program Design and Implementation

The current analysis has assumed full implementation across all buildings. In reality, the Regional District of Nanaimo does not have authority to mandate energy efficiency requirements that exceed the BC Building Code. A range of alternative enforcement models are being explored throughout the Province in association with the Community Action of Energy Efficiency (CAEE). Opportunities for density bonusing, and performance based hook-up fees may be considered as implementation tools for consideration. In addition, traditional land use planning approaches to support compact community development remain a key implementation tool to support the Green Building-Complete Community scenario.

6. CONCLUSIONS

The Regional District of Nanaimo has commissioned this analysis to better understand the range of impacts, and financial implications of promoting green buildings in its jurisdiction.

The objectives of this project are to:

- Identify the range of impacts associated with new construction in the RDN over the next 20 years;
- Quantify the annual and cumulative impacts of new construction if it were built to a conventional standard;
- Compare these results to the impacts of the same construction if it were built to an identified standard for green building (corresponding to the "Green Buildings scenario, and
- Explore the added environmental benefits of green buildings in compact communities.

A summary of the environmental benefits of the Green Buildings and Green Buildings - Compact Communities scenarios is presented in Table 16. This analysis shows there is significant opportunity to reduce the footprint of development across all environmental aspects. In particular, GHG emissions are reduced 16% and 36% for the Green Buildings and Green Buildings - Compact Communities scenarios, respectively.

Table 16: Impact of Green scenarios [% Improvement relative to BAU]

Environmental Aspect	Green Buildings Scenario	Green Buildings - Compact Communities Scenario
Building Energy Use [1000 GJ/year]	29%	48%
Transportation Energy Use [million litres/year]	0%	30%
Water Consumption [1,000 m^3/year]	43%	48%
Waste Water [1,000 m^3/year]	44%	48%
Solid Waste [Tonnes/year]	42%	55%
GHG Emissions [Tonnes/year]	16%	36%
Land Use for Housing [Ha]	0%	13%

The financial implications of the green building scenarios are summarised in Table 17. The investment requirements and savings opportunities are significant.

Table 17: Financial Implications of Green Building Scenarios [$ million]

	Green Buildings Scenario	Green Buildings - Compact

		Communities Scenario
Operating Savings in 2031 (Relative to BAU) [%]	24%	40%
Incremental Capital Costs (Relative to BAU) [$]	640	820
NPV (@6% discount Rate) (Relative to BAU) [$]	180	590

6.1 Recommendations

Based on this work, the environmental and financial benefits of implementing a green building strategy are significant. It is recommended the RDN develop a program designed to achieve the green building objectives, with an emphasis on supporting construction of green buildings within the urban containment boundary.

To be successful, program design will need to address a range of capital, knowledge and institutional barriers. Further analysis is recommended to address these program design issues.

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Data References

Data	Source/Reference
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Data	Source/Reference
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APPENDIX A – DETAILED ASSUMPTIONS

This study deals only with new construction. In general residential buildings have a 60 year life and commercial buildings have an 80 year life. Buildings in both sectors require periodic maintenance.

Time Period

- 20 years, starting 2011.
    - Rationale: population projection data from Urban Futures Population and Housing Change report is provided every five years, in Census years. In addition, the BC Energy Efficient Buildings Plan outlines an EnerGuide 80 target for all new single detached dwellings and row houses by 2010. By 2011, it is assumed that 100% of new single detached dwellings and row houses meet the EGH 80 standard.

Population Projections

Population estimates were taken from the Population and Housing Change in the Nanaimo Region, 2006 to 2036, Urban Futures, October 2007.

Table 18: Projected Population, 1991 to 2036

Year	1991	1996	2001	2006	2011	2016	2021	2026	2031	2036
Population	104,400	126,300	132,400	144,300	158,700	175,200	192,100	207,600	220,600	231,100

In the Green Buildings - Compact Communities Scenario, it is assumed that by 2031, 83% of the population resides inside the UCB, representing a shift of 25% from those living outside the UCB (Table 19). As the population ages, combined with higher costs of fossil fuels, there will be a natural migration to areas with increased access to amenities.

Table 19: Green Buildings - Compact Communities Population Distribution

Population	2011	2031
Inside UCB	106,300	185,000
Outside UCB	52,400	35,600
RDN (total)	158,700	220,600
Proportion within UCB	67%	83%

Land Area and Density

Total developable land area within the RGS study area is 92,392.8 ha. This includes land designated as Industrial Areas, Resource Lands and Open Spaces, Rural Residential, and Urban Areas. The 2007 Land Inventory and Residential Capacity Analysis report provides the following estimates of total and developable area within the UCB (Table 20). The land area allows for estimates of population and housing density to be made (Table 21). Density was used in determining the impacts of land use on transportation.

Table 20: Land Area in UCB

Land Use Designation	Total Net Area Inside UCB (ha)	Total Developable Area Inside UCB (ha)
Urban	8,160	6,870
Total	9,540	8,080

Table 21: Estimated Population and Housing Density for Green Buildings - Compact Communities Scenario inside UCB only

	2011	2016	2021	2026	2031
Total Developable Area (8080ha)					
Population Density (people/ ha)	14.4	17.0	19.4	21.6	22.9
Housing Density (units/ ha)	6.3	7.9	9.5	11.1	12.7
Developable Urban Area (6,870 ha)					
Population Density (people/ ha)	16.9	20.0	22.8	25.4	26.9
Housing Density (units/ ha)	7.4	9.3	11.2	13.1	15.0

Building Archetypes

Residential, commercial and institutional buildings are included in the analysis. Municipal and industrial buildings are outside the scope of this project.

Residential

Eight residential dwelling archetypes were identified in the Land Inventory & Residential Capacity Analysis for 2006. For the purposes of this study and as reported in the build-out analysis, we have assumed there are three main residential dwelling archetypes:

- Single family detached,
- Semi-detached/row/townhouse/duplex[14], and
- Apartment – low rise/high rise.

In 2006, approximately 44% of housing in the RDN was constructed prior to 1980. It is expected that this is representative of the age of housing stock within the UCB. Based on this, for this study it is assumed that as density and development increases within the UCB, approximately 30% of the single family housing stock would be redeveloped into higher density housing forms.

Commercial & Institutional

Commercial and institutional building archetypes are included in this analysis. We have included all commercial and institutional building types as outlined in the BC Hydro Conservation Potential Review – Commercial Sector, 2007 report. These are listed below.

[14] Includes mobile homes.

Commercial building archetypes include:

- Large Office
- Medium Office
- Large Non-Food Retail
- Medium Non-Food Retail
- Food Retail
- Large Hotel
- Medium Hotel/Motel
- Restaurant
- Warehouse
- Small Office
- Small Non-Food Retail
- Other Small Commercial

Institutional building archetypes include:

- Large School
- Medium School
- University/College
- Hospital
- Nursing Home

Recreational facilities are not included as they are generally considered to be municipal facilities. Airports are not included as they are specialized facilities.

Building Stock Baseline

Residential

Residential building stock numbers are based on the Land Inventory and Residential Capacity Analysis. For the Business As Usual and Green Building scenarios, we have assumed a linear rate of growth in the residential housing stock.

Table 22: Residential Building Stock Baseline

	2006		Total Housing Capacity		2036[15]	
Structural Type	**Number of Dwellings**	**Share of Units (%)**	**Number of Dwellings**	**Share of Units (%)**	**Number of Dwellings**	**Share of Units (%)**
Single-detached	43,300	73	72,700	67	73,800	68
Other Ground Oriented[16]	8,700	14	16,100	14	20,100	18
Apartment	7,100	12	19,500	18	16,900	15
Total	59,200	100	108,300	100	108,300	100

Commercial and Institutional

Commercial and institutional floor area is based on the 2007 Conservation Potential Review (CPR) – Commercial Sector report. The CPR estimates floor area for four service regions in BC, one of which is Vancouver Island. Floor area estimates for the RDN were scaled based on the ratio of RDN population to Vancouver Island (VI) population.

- RDN Population (2006): 144,300
- VI Population (2006): 701,100
- Population Ratio (RDN/VI): 0.2058

[15] Based on Urban Futures Institute's baseline projection as outline in the 2007 report "Population and Housing Change in the Nanaimo Region, 2006 to 2036".

[16] Includes townhouses and mobile homes.

The ratio of commercial floor area per 1,000 people will remain constant over the study period.

We have assumed that institutional floor area per 1,000 people (e.g. schools, hospitals and university/colleges) will remain constant over the study period.

Table 23: 2006 Floor Area Estimates for RDN, Commercial and Institutional Buildings[17]

		VI Estimated Floor Area		RDN Estimated Floor Area	
Commercial		**ft²**	**m²**	**m²**	**m²/1000 people**
	Large Office	5,589,000	519,000	106,000	3,600
	Medium Office	3,183,000	295,0001	60,000	2,000
	Large Non-Food Retail	1,953,000	181,000	37,000	1,200
	Medium Non-Food Retail	1,893,000	175,000	36,000	1,200
	Food Retail	2,476,000	230,000	47,000	1,600
	Large Hotel	1,457,000	135,000	27,000	940
	Medium Hotel/Motel	1,034,000	96,000	19,000	670
	Restaurant	926,000	86,000	17,000	600
	Warehouse	496,000	46,000	9,000	320
	Small Office	20,029,000	1,860,000	383,000	12,000
	Small Non-Food Retail	15,748,000	1,463,000	301,000	10,000
	Other Small Commercial	24,393,000	2,266,000	466,000	15,000
	Total	79,181,000	7,355,000	1,514,000	n/a
Institutional					
	Large School	4,734,000	439,000	90,000	3,000
	Medium School	3,628,000	337,000	69,000	2,300
	University/College	4,609,000	428,000	88,000	2,900
	Hospital	3,018,000	280,000	57,000	1,900
	Nursing Home	753,000	70,000	14,000	500
	Total	16,744,000	1,555,000	320,000	n/a

Building Standards and Consumption

Many of the reductions in energy, water, wastewater and solid waste are dependent on consumer behaviour as well as building design. For this study, we are assuming that building tenants' behaviour would meet the assumptions of the study. All reductions are assumed to be achievable. To ensure that the maximum reductions are met, programs that support reduction activities and behaviour need to be in place.

- Building standards remain constant over the 20-year study period.
- Conventional standards are:
    - Residential – EnerGuide 80
    - Commercial and Institutional – ASHRAE 90.1-2004

[17] Scaling floor areas from Vancouver Island to the Regional District of Nanaimo provides a distorted picture of the distribution of commercial and institution space. This is the best available information, and will be revised when comprehensive RDN specific data is provided by BC Assessments.

- Green building standards are:
    - Residential – EnerGuide 85
    - Commercial and Institutional – LEED Gold (minimum 6 points in Energy & Atmosphere)

Summary

Table 24: Summary of Assumptions

	Residential	Commercial	Institutional
Business As Usual (2011)			
Energy	EnerGuide 80	ASHRAE 90.1-2004	ASHRAE 90.1-2004
Potable Water	Average use per connection: 0.81 m^3/connection/day Indoor: 77% of consumption Outdoor: 23% of consumption	Varies	
Solid Waste	Disposal: 196 kg/capita/yr (SFD) Diversion rate: 57% (2003)	Disposal: 209 kg/capita/yr Diversion rate: 75%	
Wastewater	84 % of potable water consumed[18]	84 % of potable water consumed	84 % of potable water consumed
Transportation	Not applicable	Not applicable	Not applicable
Green Buildings			
Standard	EnerGuide 85	LEED Gold (minimum 6 points in Energy & Atmosphere)	LEED Gold (minimum 6 points in Energy & Atmosphere)
Energy	20% reduction	47% reduction	47% reduction
Potable Water	Indoor: 40% reduction Outdoor: 20% reduction	Indoor & Outdoor: 48% reduction	Indoor & Outdoor: 48% reduction
Solid Waste	Disposal: 114 kg/capita/year Diversion rate: 75%	Disposal: 121 kg/capita/year	
Wastewater	84 % of potable water consumed	84 % of potable water consumed	84 % of potable water consumed
Transportation	Not applicable	Not applicable	Not applicable
Green Buildings - Compact Communities			
Standard	EnerGuide 85	LEED Gold (minimum 6 points in Energy & Atmosphere)	LEED Gold (minimum 6 points in Energy & Atmosphere)
Energy	20% reduction	47% reduction	47% reduction
Potable Water	Indoor: 40% reduction Outdoor: 20% reduction	Indoor: 48% reduction Outdoor: no change	Indoor: 48% reduction Outdoor: no change
Solid Waste	Disposal: 114 kg/capita/year(SFD) Diversion rate: 75%	Disposal: 121 kg/capita/year	
Wastewater	84 % of potable water consumed	84 % of potable water consumed	84 % of potable water consumed
Transportation	Support growth within the urban containment boundary Implement targeted transportation demand management and support public transit		

[18] Based on a review of the literature, it is estimated that approximately 84% of fresh potable water is treated by sewers. However, this estimate varies by location and it is recommended further analysis be completed for the RDN to assess the sewer flows.

Energy

- Residential dwelling energy consumption is based on past work completed for the City of Surrey and is assumed to be similar to residential energy consumption in the RDN (see Table 25). Surrey and the RDN are fairly similar in housing mix, size of dwellings, average household size, median income and climate (daily average temperatures).
- Based on the 2007 Residential CPR, the split between dwellings with electric and non-electric heat was determined (see Table 26).
- New residential dwellings will be constructed to EnerGuide 85, resulting in a 20% reduction in energy consumption over conventional buildings.

Table 25: Current Residential Energy Consumption by Dwelling and Space Heating Type

	Electric Space Heat		Non-Electric Space Heat	
	Electricity	Natural Gas	Electricity	Natural Gas
Dwelling Type	kWh/yr	GJ/yr	kWh/yr	GJ/yr
Single Family	21,000	0	10,000	114
Semi-detached	12,000	0	8,000	60
Apartment	8,200	0	4,200	50

Table 26: Residential Space Heating Breakdown by Fuel Type

	Breakdown by Unit (%)	
	Electric Heat	Non-Electric Space Heat
Single Family	53%	47%
Semi-detached	59%	41%
Apartment	62%	38%

- Commercial and institutional energy consumption is based on past work completed for the GVRD and is assumed to be similar to energy consumption in the RDN (see Table 27).
- New buildings will be constructed to LEED Gold standards, resulting in 47% energy reductions.
- Fuel share (electric/natural gas split) is based on the 2007 CPR (see Table 28).

Table 27: Commercial and Institutional Annual Energy Consumption (GJ/m^2)

		Electricity	Natural Gas
		GJ/sq m	GJ/sq m
Commercial			
	Large Office	1.0	0.60
	Medium Office	1.01	0.60
	Large Non-Food Retail	1.0	0.60
	Medium Non-Food Retail	1.0	0.60

		Electricity	Natural Gas
		GJ/sq m	GJ/sq m
	Food Retail	2.71	0.92
	Large Hotel	1.21	0.80
	Medium Hotel/Motel	1.21	0.80
	Restaurant	1.24	3.66
	Warehouse	0.34	1.20
	Small Office	1.01	0.60
	Small Non-Food Retail	0.91	1.20
	Other Small Commercial	0.91	1.20
Institutional			
	Large School	0.28	1.90
	Medium School	0.28	1.90
	University/College	0.66	1.00
	Hospital	0.68	1.10
	Nursing Home	1.21	1.10

Table 28: Commercial and Institutional Electric Fuel Share

		Space heating	Domestic Hot Water	Food service equipment
Commercial				
	Large Office	15%	50%	75%
	Medium Office	20%	55%	75%
	Large Non-Food Retail	13%	60%	50%
	Medium Non-Food Retail	12%	60%	50%
	Food Retail	20%	65%	75%
	Large Hotel	18%	10%	25%
	Medium Hotel/Motel	16%	30%	35%
	Restaurant	10%	40%	25%
	Warehouse	12%	65%	100%
	Small Office	25%	55%	100%
	Small Non-Food Retail	13%	70%	100%
	Other Small Commercial	12%	66%	79%
Institutional				
	Large School	13%	60%	75%
	Medium School	15%	60%	100%
	University/College	14%	50%	50%
	Hospital	5%	15%	50%
	Nursing Home	35%	60%	50%

Water and Wastewater

Average use per residential connection:

- 0.81 m3/connection/day
- Indoor: 77% of consumption

- Outdoor: 23% of consumption

Future residential consumption of potable water will be reduced by:

- 40% for indoor use, and
- 20% for outdoor use.[19]

Commercial and institutional water consumption is based on the GVRD report and outlined in Table 29. It is assumed that the majority of water consumption is for indoor use. Future consumption of potable water is estimated to be reduced by 48% in commercial and institutional buildings.

Table 29: Estimated Annual Potable Water Consumption by Sector

		Consumption (1,000 cu m/1,000 sq m)[20]
Commercial		
	Large Office	17.2
	Medium Office	17.2
	Large Non-Food Retail	17.2
	Medium Non-Food Retail	17.2
	Food Retail	8.4
	Large Hotel	11.6
	Medium Hotel/Motel	11.7
	Restaurant	5.9
	Warehouse	0.8
	Small Office	2.7
	Small Non-Food Retail	1.7
	Other Small Commercial	1.7
Institutional		
	Large School	2.9
	Medium School	2.9
	University/College	4.0
	Hospital	13.4
	Nursing Home	2.1

Table Notes:

1. Medium Office, Medium Non-Food Retail and Large Non-Food Retail sectors are assumed to have the same water consumption as the Large Office.
2. Small Non-Food Retail and Other Small Commercial sectors are assumed to have the same water consumption.
3. Large School and Medium School sectors are assumed to have the same water consumption.

Wastewater flows are assumed to be 84% of potable water consumed.

- Based on a review of the literature, it is estimated that approximately 84% of fresh potable water is treated by sewers. However, this estimate varies by location and it is recommended further analysis be completed for the RDN to assess the sewer flows.

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[19] Estimated based on the Capital Regional District's reductions in outdoor water use for Stage 1 and outdoor watering restrictions.

[20] For example, a large office consumes approximately 17,250 m^3 per 1,000 m^2 of floor area.

Solid Waste

- The future diversion rate is 75% and remains constant over the study period (based on RDN's Solid Waste Management Plan – Zero Waste Plan).
- Total waste generated by each sector remains constant over the study period and is based on estimates of solid waste generated currently (see Table 30).

Table 30: Solid Waste Estimates (kg/capita/year)

	Total Generated	Disposed	
Sector		**BAU**	**Green Scenarios**
Residential	455	196	114
Commercial & Institutional	486	209	121
Construction & Demolition	93	40	23
Total disposed	1,034	445	258
Diversion Rate	-	57%	75%

Table Note: Commercial and institutional waste and multi-family waste are collected in dumpsters and currently there is no method to determine how much waste is generated by each sector. Multi-family (i.e. townhouses and low/high rises) waste will be included in Commercial & Institutional sector in the analysis for consistency.

Operating Costs

Operating costs are based on total annual energy and water consumption, and solid waste disposal. Costs are reported in 2008 dollars and assumed constant over the study period.

Table 31: Operating Costs (2008 $)

	Amount	Units
Electricity	$18.10[21]	$/GJ
Natural Gas	$14.30	$/GJ
Water & Wastewater	$1.00	$/m^3
Solid Waste	$70.00	$/tonne

Maintenance and Repair Costs

Maintenance and repair costs for typical commercial and institutional buildings are based on BOMA Canada's 2004 Experience Exchange Report. On average a typical Canadian building's operation costs is approximately $79.19/m^2 (2004 $). Approximately 25% of this can be attributed to maintenance and repair costs, or about $21.14/m^2 (2008 $).[22]

Currently, it is unknown if green buildings contribute to a decrease in maintenance and repair costs. Both the LEED® and Built Green™ building rating systems include credits for durability although there have been cases where green buildings have failed prematurely. Anecdotally, some aspects of green buildings may require increased maintenance; for instance, high efficiency boilers, green roofs and sophisticated indoor air quality equipment

[21] Electricity cost per GJ is equivalent to 6.55 cents per kWh. Note that BC Hydro is proposing a two-step rate structure that would become effective October 1, 2008 if approved by the BC Utilities Commission. However, for the purposes of this study, a constant rate has been assumed.

[22] Adjusted for inflation.

require more maintenance and may contribute to a higher overall cost of repair. Therefore, maintenance and repair costs are not included in the analysis – it is assumed that they are the same across all scenarios.

Residential maintenance and operating costs are typically borne by the homeowner and therefore not included.

Transportation

Transportation impacts were evaluated only for the Green Buildings - Compact Communities Scenario's increased density within the UCB only. It was assumed that due to lower densities and lack of transit availability, the majority of residents residing outside the UCB would continue to favour automobile transportation over other modes.

Currently, almost 90% of residents within the RDN commute to work in a vehicle (see Table 32), with only 3% taking transit to work. However, within the UCB almost 80% of residents live within 400 metres of a transit stop.

Table 32: Mode of Transportation to Work, Nanaimo CD (2006 Census)

	Total	Proportion of Total
Total employed labour force 15 years and over with a usual place of work or no fixed workplace address	56,070	100%
Car, truck, van, as driver	44,970	80%
Car, truck, van, as passenger	3,960	7%
Public transit	1,475	3%
Walked or bicycled	4,705	8%
All other modes	950	2%

Estimates of GHGs due to passenger vehicles and transit in 2031 were determined based on a greenhouse gas emissions model, using local data from the RDN where possible and supplemented by transit studies completed by the Capital Regional District. The following table includes the assumptions used in the calculation of GHGs.

Table 33 Assumptions for Green Buildings - Compact Communities Transportation Calculations

Variable	2006	Rationale/Source
Population	101,500	2006 population within UCB
Daily person trips/capita	2.2	Average of RDN Transportation and Mobility Report (0.96 daily trips per person) and CRD Travel Survey, March 2007 (3.44 daily trips per person).
Daily transit trips/capita	0.1	Calculated from 2006 Census, Nanaimo (CD), mode share data and daily person trips.
Daily transit mode share	2.6%	2006 Census, Nanaimo (CD)
Daily non-motorized mode share	10%	Calculated from 2006 Census, Nanaimo (CD), mode share data and daily person trips.
Auto occupancy	1.1	Calculated from 2006 Census, Nanaimo (CD), Mode of Transportation to Work.

Average trip length (km)		
Auto	7.1	Based on 2006 CRD Travel Study.
Transit	8.1	Based on 2006 CRD Travel Study.

Transit trips per capita for the Green Buildings - Compact Communities Scenario were estimated based data from the Capital Regional District Travel Study. [23]

Table 34: Estimate of Transit Trips Per Capita for UCB

	2006	2011	2016	2021	2026	2031
Daily Transit Trips per Capita	0.06	0.07	0.08	0.10	0.11	0.11

APPENDIX B – DETAILED RESULTS

B.1 Business-As-Usual

This section reports the results of the BAU scenario and provides explanations of the results. The estimates of energy use, water consumption, wastewater and solid waste generation, and air and GHG emissions are based on new buildings constructed over the study period, i.e. the difference in existing building stock and projected total stock.

Building Forecast

By 2036, Urban Futures Institute's Population and Housing Change, October 2007 (UFI) study forecasts that there will be 108,346 residential dwelling units in the RDN. Based on this projection and the current (2006) number of residential units, the number of new dwelling units in constructed in the intervening years (2011 – 2031) was estimated (see Table 35). In addition, over the study period the proportion of single-detached dwellings declines by 5%.

Table 35: Residential Housing Projection – New Units by Dwelling Type

Housing Projections	2011	2016	2021	2026	2031
Single-detached	5,080	10,160	15,240	20,330	25,410
Other Ground Oriented	1,880	3,770	5,660	7,550	9,440
Apartment	1,630	3,260	4,890	6,520	8,150
Total	*8,600*	*17,200*	*25,800*	*34,400*	*43,000*

Estimates of commercial and institutional floor area for the RDN are based on floor areas reported in BC Hydro's 2007 Conservation Potential Review (CPR) – Commercial Sector report. The CPR estimates floor area for four service regions in BC, one of which is Vancouver Island. Floor area estimates for the RDN were scaled based on the ratio of RDN population to Vancouver Island population. Floor area estimates per 1,000 people are assumed to remain constant over the study period. Population projections from the UFI

[23] http://www.crd.bc.ca/regionalplanning/transportation/origindestination.htm

report were used estimate the construction of new floor area space over the study period (see Table 36).

Note that this is a conservative estimate as the RDN has a disproportionately high level of commercial floor space compared to other regions on Vancouver Island. However, the purpose of this analysis is to highlight the differences in impacts between commercial buildings constructed to the "status quo" standards and those constructed to a green building standard. Commercial and institutional floor area is the same for all scenarios.

Based on the above assumptions, floor area over the study period grows at a linear rate. The largest commercial floor area is "Other Small Commercial", i.e. not food retail or office space. Figure 17 shows the breakdown by commercial market sector. Figure 18 shows the breakdown of institutional floor area by sector.

Table 36: Commercial and Institutional Floor Area Projections – New Construction Only (m^2)

	2011	2016	2021	2026	2031
Commercial					
Large Office	10,000	22,000	35,000	46,000	56,000
Medium Office	6,000	13,000	20,000	26,000	32,000
Large Non-Food Retail	3,000	8,000	12,000	16,000	19,000
Medium Non-Food Retail	3,000	7,000	11,000	15,000	19,000
Food Retail	4,000	10,000	15,000	20,000	25,000
Large Hotel	2,000	5,000	9,000	12,000	14,000
Medium Hotel/Motel	1,000	4,000	6,000	8,000	10,000
Restaurant	1,000	3,000	5,000	7,000	9,000
Warehouse	1,000	2,000	3,000	4,000	5,000
Small Office	38,000	82,000	126,000	168,000	202,000
Small Non-Food Retail	30,000	64,000	99,000	132,000	159,000
Other Small Commercial	46,000	100,000	154,000	204,000	246,000
Total	*151,000*	*324,000*	*501,000*	*664,000*	*801,000*
Institutional					
Large School	9,000	19,000	29,000	39,000	47,000
Medium School	6,000	14,000	22,000	30,000	36,000
University/College	8,000	18,000	29,000	38,000	46,000
Hospital	5,000	12,000	19,000	25,000	30,000
Nursing Home	1,000	3,000	4,000	6,000	7,000
Total	*32,000*	*68,000*	*106,000*	*140,000*	*169,000*

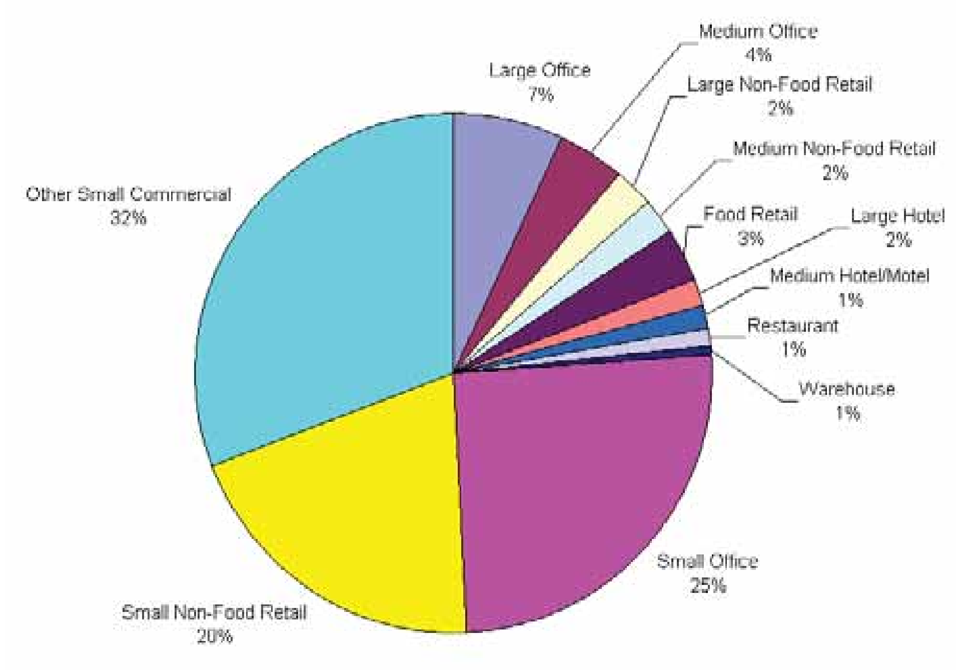

Figure 17: Commercial Floor Area Breakdown by Sector

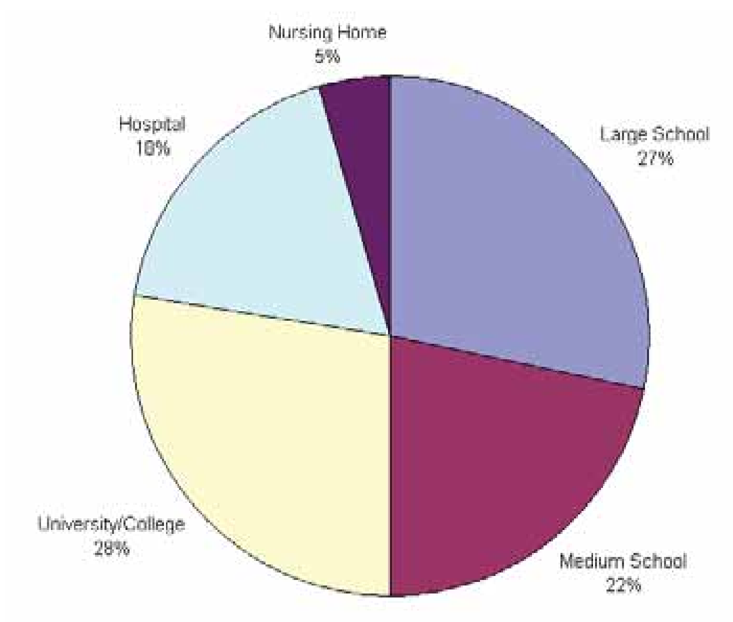

Figure 18: Institutional Floor Area Breakdown by Sector

Energy Forecast

Energy consumption for each sector's buildings is reported in Table 37. The totals include both natural gas and electricity consumption.

Residential energy consumption was estimated based on housing projections and the fuel split (see Table 26). Commercial and institutional energy consumption was estimated based on natural gas and electricity data from buildings in the Lower Mainland that were audited. Energy consumption is assumed to be similar between the Lower Mainland and the RDN as climate and economies are similar. Figure 19 shows the incremental annual energy use in 2031 of new commercial and institutional buildings constructed since 2006 by type and market sector.

Table 37: BAU Energy Consumption by Sector, (GJ/yr)

	2011	2016	2021	2026	2031
Residential	747,000	1,495,000	2,243,000	2,991,000	3,738,000
Commercial	238,000	510,000	788,000	1,044,000	1,259,000
Institutional	37,000	81,000	125,000	165,000	200,000
Total	*1,024,000*	*2,087,000*	*3,157,000*	*4,201,000*	*5,198,000*

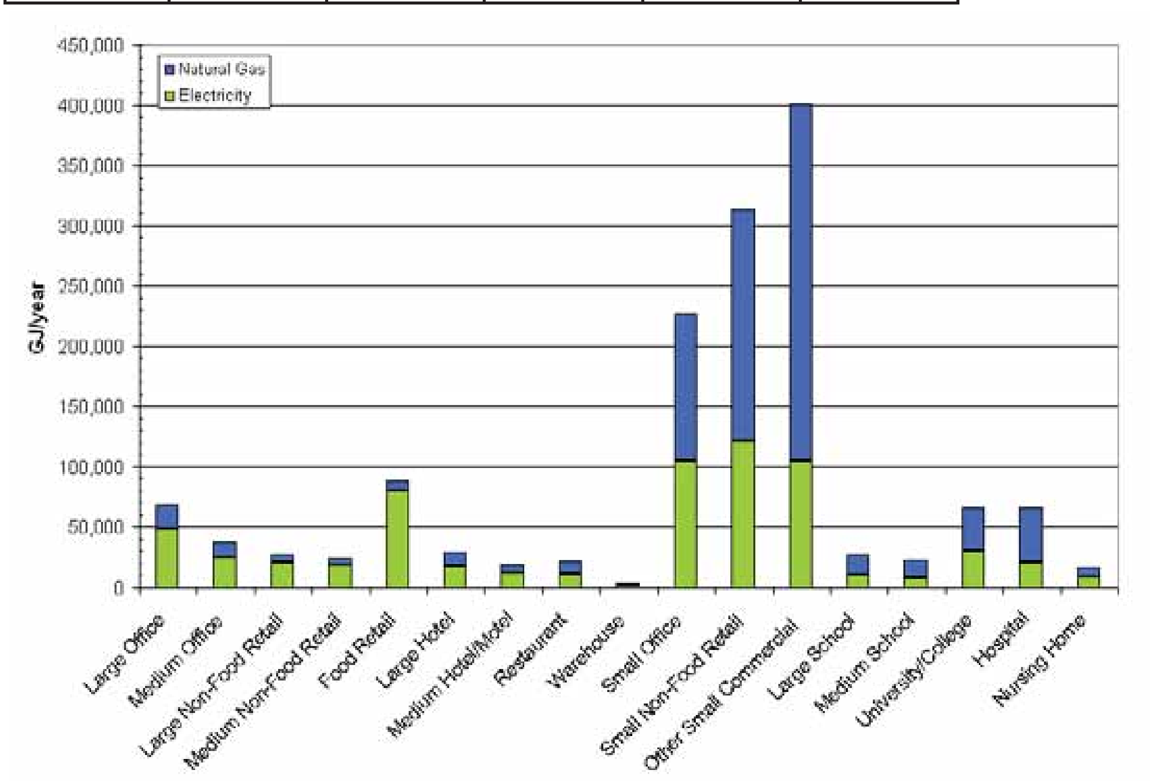

Figure 19: BAU Scenario – Incremental Commercial and Institutional Energy Consumption – 2031 (GJ/year)

Water & Wastewater Forecast

Water consumption for residential dwellings was estimated based on the RDN Water Service Area Consumption Spreadsheet (2001-2007) seven-year annualized average for residential connections, determined to be 0.81 m^3 per connection per day. It was assumed that a connection was equivalent to a dwelling. Based on past studies, indoor water consumption accounts for approximately 77% of total consumption. Water consumption for Other Ground Oriented and Apartments was adjusted for lack of outdoor irrigation.

Commercial and institutional water consumption was estimated based on estimates of annual water use per 1,000 m^2 per year by sector as outlined in the Strategic Assessment of Resource and Economic Impacts of Green Buildings in Greater Vancouver (2003).

Based on the study assumptions, about 70% of water consumption in the region is due to the residential sector (see Table 38) in 2011. Annually, total water consumption averages 214 m^3 per person, across all sectors.

Table 38: BAU Scenario – BAU Water Consumption by Sector (1,000s m^3/yr)

	2011	2016	2021	2026	2031
Residential	2,300	4,600	6,900	9,200	10,100
Commercial	760	1,600	2,500	3,300	4,000
Institutional	164	350	540	710	860
Total	3,200	6,500	9,900	13,200	15,000

Wastewater generation is estimated to be 84% of potable water consumption (Table 39).

Table 39: BAU Scenario – BAU Wastewater Generation by Sector (1000s m^3/yr)

	2011	2016	2021	2026	2031
Residential	1,900	3,800	5,700	7,700	8,500
Commercial	630	1,300	2,100	2,800	3,300
Institutional	130	290	450	600	720
Total	2,700	5,500	8,300	11,100	12,600

Solid Waste Disposal Forecast

Solid waste estimates are based on the 2003 Solid Waste Management Plan per capita disposal rates for the residential, commercial and institutional, and construction and demolition sectors, representing a 57% diversion rate. Table 40 shows total tonnes of waste disposed over the study period, by sector. Note that multi-family waste is typically included in the Commercial and Institutional waste stream. However, estimates of multi-family waste were extracted from the Commercial and Institutional waste stream based on a Sheltair study for Metro Vancouver that estimated that approximately 24% of the total is multi-family waste.

Note that due to collection practices, multi-family waste is typically included in the commercial and institutional sector. However in this study, estimates of waste from Other Ground Oriented and Apartment dwelling types were developed.

Table 40: BAU Scenario – BAU Solid Waste Generated by Sector (tonnes/year)

	2011	2016	2021	2026	2031
Residential	1,960	4,200	6,500	8,500	10,300
Commercial & Institutional	2,730	5,840	9,000	11,900	14,400
Construction & Demolition	580	1,240	1,900	2,500	3,000
Total	*5,270*	*11,280*	*17,400*	*23,000*	*27,800*

GHG Emissions Forecast

The GHG emissions from energy consumption and solid waste decomposition were estimated based on accepted emission factors for electricity generation, natural gas combustion and solid waste decomposition (in landfills). Table 41 reports tonnes of GHG emission per year.

Table 41: BAU Scenario GHG Emissions (tonnes/year)

	2011	2016	2021	2026	2031
GHG (Energy)	29,000	59,800	90,600	120,600	137,000
GHG (Solid Waste)	2,400	5,100	7,900	10,500	12,700
Transportation	38300	76600	114900	153200	191,500
Total	69,700	141,500	213,400	284,300	339,200

B.2 Green Buildings Scenario Development

This section reports the results of energy use, water consumption, wastewater and solid waste generation estimated for green buildings. Note that the results assume that building tenants operate the buildings in the way they were designed.

Building Forecast

Residential housing projections are the same as the Business As Usual scenario (see Table 35). Commercial and institutional floor space estimates are the same as the Business As Usual scenario (see Table 36).

Energy Forecast

Energy consumption for each sector's buildings is reported in Table 42. The totals include both natural gas and electricity consumption.

Residential energy consumption was estimated based on the BAU scenario and estimated achievable reductions from constructing to an EnerGuide 85 standard resulting in a 20% reduction for single family and other ground oriented buildings; apartments buildings would be built to the LEED® Gold standard resulting in a 47% reduction.

Commercial and institutional energy consumption was estimated based BAU and estimated achievable reductions that would result from meeting LEED® Gold certification resulting in an estimated 47% reduction in energy use over ASHRAE 90.1.

Table 42: GB Building Energy Consumption by Sector, (GJ/yr)

	2011	2016	2021	2026	2031
Residential	579,000	1,158,000	1,737,000	2,317,000	2,896,000
Commercial	126,000	270,000	417,000	553,000	667,000
Institutional	20,000	42,000	66,000	87,000	106,000
Total	*725,600*	*1,472,000*	*2,222,000*	*2,958,000*	*3,669,000*

Water & Wastewater Forecast

Water consumption for residential dwellings was estimated based on the RDN Water Service Area Consumption Spreadsheet (2001-2007) seven-year annualized average for residential connections, determined to be 0.81 m^3 per connection per day and estimated percentage reductions achievable in green buildings. It was assumed that 77% of water use was for indoor appliances and 23% for outdoor irrigation. Indoor achievable reductions are estimated to be 40% and outdoor reductions 20%. Other ground oriented dwellings and apartments were assumed to have no outdoor water use.

Commercial and institutional water consumption was estimated based the Business As Usual Scenario and estimated reductions in consumption that can be expected from LEED® Gold buildings. For the purposes of this study, it was assumed that outdoor water use is negligible in the commercial and institutional sectors.

Based on the study assumptions, approximately 74% of water consumption in the region is due to the residential sector (see Table 43) in 2011. Annually, total water consumption averages 128 m^3 per person, across all sectors.

Table 43: GB Water Consumption by Sector (1000s m^3/yr)

	2011	2016	2021	2026	2031
Residential	1,450	2,900	4,350	5,800	5,950
Commercial	390	840	1,300	1,730	2,090
Institutional	80	180	280	370	450
Total	1,930	3,930	5,940	7,900	8,490

Wastewater generation is estimated to be 84% of potable water consumption (Table 44).

Table 44: GB Wastewater Generation by Sector (1000s m^3/yr)

	2011	2016	2021	2026	2031
Residential	1,220	2,440	3,660	4,800	5,000
Commercial	330	710	1,100	1,460	1,760
Institutional	70	150	240	310	380
Total	1,620	3,300	4,990	6,600	7,140

Solid Waste Disposal Forecast

Solid waste estimates for this scenario are based on a 75% diversion rate – RDN's Zero Waste Target – and per capita disposal rates for the residential, commercial and institutional, and construction and demolition sectors. On average, 212 kilograms per capita per year disposed by all sectors. Table 45 shows total tonnes of waste disposed over the study period, by sector. Note that due to collection practices, multi-family waste is included in the commercial and institutional sector. However in this study, estimates of waste from Other Ground Oriented and Apartment dwelling types were developed.

Table 45: GB Solid Waste by Sector (tonnes/year)

	2011	2016	2021	2026	2031
Residential	970	2,070	3,210	4,250	5,120
Commercial & Institutional	1,750	3,760	5,800	7,680	9,270
Construction & Demolition	330	720	1,110	1,470	1,770
Total	*3,000*	*6,550*	*10,130*	*13,400*	*16,170*

GHG Emissions Forecast

The GHG impacts of energy consumption and solid waste decomposition were estimated based on accepted emission factors for electricity generation, natural gas combustion and solid waste decomposition (in landfills). Table 46 reports tonnes of emission per year.

Table 46: GB Greenhouse Gas Emissions (tonnes/year)

	2011	2016	2021	2026	2031
GHG (Energy)	20,600	41,900	63,200	84,000	89,300
GHG (Solid Waste)	1,500	3,200	4,900	6,400	7,800
GHG (transportation)	38,300	76,600	114,900	153,000	191,000
Total	60,400	121,600	183,000	243,000	286,000

B.3 Green Buildings - Compact Communities: Sustainable Land Use and Transportation

Building Forecast

Housing projections for the Green Buildings - Compact Communities Scenario were developed based on the following assumptions:

- In 2006, 67% of the population resided within the UCB. By 2031, 25% of the population outside of the UCB moves to inside the UCB resulting in 84% of the 2031 population living within the UCB.
- After 2011, all new development occurs within the UCB and no new single family dwellings are built within the UCB after 2016.
- By 2031, 30% of the single family dwellings (i.e. those that existed in 2011) have been redeveloped into higher density housing forms.
- Average household size decreases throughout the study period (see Table 47).
- By 2031, a total of 120,000 dwelling units will be required, an increase of 17,700 units over the BAU and GB scenarios. This is due to a shift to higher density housing forms, which have lower household sizes than single family dwellings.
- In 2031, other ground oriented dwellings are the predominant housing form with single family dwellings making up only 31% of the housing stock compared to 73% in 2006 (see Figure 20).
- The number of dwelling units is expected to increase/decrease linearly over the study period (see Table 48).

Table 47: Average Household Size

Dwelling Type	2006	2011	2016	2021	2026	2031
Single-detached	2.4	2.4	2.4	2.3	2.3	2.2
Other Ground Oriented	2.09	2.0	2.0	1.9	1.9	1.8

Apartment	1.6	1.6	1.5	1.5	1.4	1.4

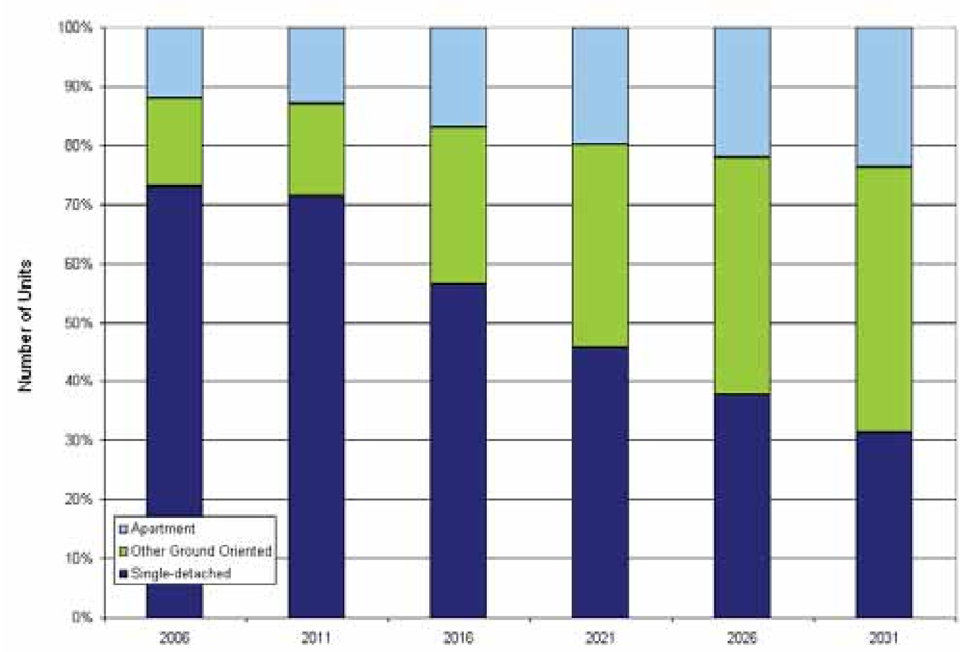

Figure 20: GB-CC Proportion of Housing Stock by Dwelling Type

Table 48: GB-CC Residential Housing Projection – Increase in Units by Dwelling Type

Dwelling Type	2011	2016	2021	2026	2031
Single-detached	5,000	2,300	-300	-3,000	-5,700
Other Ground Oriented	1,800	12,7000	23,500	34,400	45,200
Apartment	1,600	6,500	11,400	16,300	21,200
Total	8,600	21,600	34,600	47,700	60,700

Table 48 shows a decrease of single family homes in the UBC in the years 2021 to 2031, corresponding to redevelopment of existing single family homes into row style and apartment type dwellings.

Energy Forecast

Energy consumption for each sector's buildings is reported in Table 49. Residential energy consumption was estimated based on the BAU scenario and estimated achievable reductions from constructing to an EnerGuide 85 standard resulting in a 20% reduction for single family and other ground oriented buildings; apartments buildings would be built to the LEED® Gold standard resulting in a 47% reduction.

Table 49: GBCC Energy Consumption by Segment (GJ/yr)

	2011	2016	2021	2026	2031
Residential	579,000	983,000	1,387,000	1,791,000	2,195,000

Commercial	126,000	270,000	418,000	553,000	668,000
Institutional	20,000	43,000	66,000	88,000	106,009
Total	725,000	1,297,000	1,871,000	2,433,000	2,969,000

Water & Wastewater Forecast

Water consumption for residential dwellings was estimated using the same methodology as the other scenarios. Based on the study assumptions, approximately 74% of water consumption in the region is due to the residential sector in 2031.

Table 50: GBCC Water Consumption (1000 m^3/year)

	2011	2016	2021	2026	2031
Residential	1,338	2,521	3,674	5,191	5,581
Commercial	395	847	1,308	1,733	2,089
Institutional	85	182	282	373	450
Total	1,819	3,550	5,263	7,297	8,121

Wastewater generation is estimated to be 84% of potable water consumption (Table 51).

Table 51: GBCC Wastewater Generation (1000 m^3/yr)

	2011	2016	2021	2026	2031
Residential	1,124	2,117	3,086	4,361	4,688
Commercial	332	711	1,099	1,455	1,755
Institutional	72	153	237	314	378
Total	1,528	2,982	4,421	6,130	6,822

Solid Waste Disposal Forecast

Solid waste estimates for this scenario are based on the same methodology as for the Green Buildings Scenario.

Table 52: GBCC Solid Waste (tonnes/year)

	2011	2016	2021	2026	2031
Residential	1,100	1,100	1,300	1,900	2,300
Commercial	1,500	3,300	5,200	6,900	8,300
Institutional	300	700	1,100	1,400	1,700
Total	3,000	5,200	7,700	10,300	12,500

Transportation Forecast

A simplified transportation demand model was developed to estimate energy use and GHG emissions from transportation. Baseline data was obtained from

- Transportation Surveys for the Capital Regional District

- Public Transit Fuel use for the RDN
- Fuel economy estimates for fleet average

A summary of the assumptions used to calculate transportation energy are summarised in Table 53. Population density is the major driver which impacts mode share and trip distances. In addition, it has been assumed that Transportation Demand Management is implemented in the GB-CC scenario, which further reduces transportation demand.

Table 53: Transportation Results – Vehicle Kilometres Travelled and GHG Emissions

		2006	2031 BAU	2031 GB-CC
Population		101,527	185,021	185,021
Pop Density		12.6	16.0	22.9
% change			27%	82%
Daily auto person trips/capita		2.2	2.1	1.8
Daily transit trips/capita		0.06	0.06	0.12
Average trip length (km)				
Auto		7.1	6.6	5.6
Transit		8.1	7.1	7
Auto Fuel Economy l/km		0.092	0.08	0.08
Auto trip km		578,835,140	929,039,625	700,155,860
Transit trip km		18,009,851	28,768,838	56,727,285
Auto trip energy	GJ	1,863,849	2,601,311	1,960,436
Auto Trip GHG	Tonnes	132,333	184,693	139,191
Transit Fuel	L	1,369,000	2,186,833	4,312,065
Transit trip energy	GJ	47,915	76,539	150,922
Transit trip GHG	Tonnes	3,402	5,434	10,715
TDM Impact		0%	0%	10%
GHG intensity	Tonne/GJ	0.071	0.071	0.071
Energy Intensity	GJ/l	0.035	0.035	0.035
Energy [million l]			77	54
Total Energy GJ		1,911,764	2,677,850	1,900,223
Total GHG		135,735	190,127	134,916

The 2031 total GHG projection from transportation is less than 2006 estimate by 819 tonnes, despite the fact that there are almost 85,000 more people in the Region, due to densification and transportation demand management benefits.

GHG Emissions Forecast

The GHG impacts of energy consumption and solid waste decomposition were estimated based on accepted emission factors for electricity generation, natural gas combustion and solid waste decomposition (in landfills). Table 46 reports tonnes of emission per year.

Table 54: GB-CC Scenario – Emissions from Energy Consumption and Solid Waste (tonnes/year)

	2011	2016	2021	2026	2031
GHG (Energy)	20,609	35,156	49,818	64,057	77,501
GHG (Solid Waste)	1,481	2,559	3,745	5,010	6,074
Transportation	26,900	53,900	80,900	107,900	135,000
Total	49,000	91,600	134,500	177,000	218,500