Salt Spring Island

CAEE Gold Project

FINAL

Energy and Greenhouse Gas Emissions Analysis for New Residential Buildings

Alison Bailie • Matt Horne

October 24, 2008

Table of Contents

Table of Tables

Introduction and Context

The Pembina Institute has been contracted to analyze a series of policy options that are intended to help Salt Spring Island to meet their targets to reduce energy consumption in new residential buildings. Salt Spring Island is participating in the Community Action on Energy and Emissions (CAEE), a provincial government policy initiative to advance the energy efficiency for new and existing buildings in both private and public sectors. Through the CAEE initiative, Salt Spring has committed to a number of targets including:

- Achieve an EnerGuide for New Houses rating of 80 for 100% of new detached, single family and row houses by 2010 (subject to bylaw adoption).

This report provides an assessment of the potential costs and benefits resulting from different levels of energy performance in new residential buildings on Salt Spring Island. Specifically, this report:

- Details the changes to building design and materials that will improve energy performance.
- Estimates the changes in construction costs resulting from changes to building design and materials, including life-cycle economic costs.
- Estimates the energy and GHG savings for average buildings and for the community.
- The report also considers the potential changes to carbon storage in forests and soils resulting from different residential development. Land clearing for buildings and building access will disturb the existing plants and soils which can lead to release of large amounts of stored carbon. Examples of how the amount of land cleared can be reduced include locating homes closer to existing roads, and placing homes closer to each other on adjacent sites.

This report complements the report, *Density Bonus and Other Policy Options for Energy Efficiency*, date July 31, 2008, prepared by Deborah Curran also for Salt Spring Island's CAEE-Gold initiative. The *Density Bonus and Other Policy Options* report describes the density bonus provisions of the *Local Government Act* and other policy options (such as a sustainability checklist), discusses their implications for energy efficiency, and makes recommendations for their application given the administrative capacity of the Islands Trust and rural land use context of the Salt Spring Island community.

Energy savings, greenhouse gas emission reductions, and cost implications

Our analysis of energy savings and cost implications is based on five scenarios that represent potential future development of new residential buildings. Each scenario has the same growth in number of housing units (70 per year) but differs in the energy performance of new buildings or the type of new buildings (single detached vs. 5-unit attached row houses). The scenarios were designed to approximate the policy options being considered by the Islands Trust and Capital Regional District.

Our results are summarized in Table 1 while the remainder of the document describes the underlying assumptions. The results in Table 1 reflect the energy savings and other results to be expected from all new homes built on Salt Spring starting in 2009 up to the year indicated in each column. In other words, the values are the sum of impacts on all new homes for each scenario – in order to show the overall cumulative impact on the community energy needs.

Table 1 also provides additional information on energy bill savings and reductions in greenhouse gas emissions for the community. The greenhouse gas savings due to changes in new home energy performance are relatively low. One of the main reasons for this is the small amount of greenhouse gas emissions associated with electricity use on Salt Spring Island that stem from the fact that so much of BC Hydro's supply comes from hydro-electricity. The values in Table 1 represent average emissions from BC Hydro. Note however that British Columbia is part of an integrated electricity system that includes Alberta and the United States. It is possible that reduced electricity use on Salt Spring Island could lead to less imported electricity and thus less coal generation in Alberta. In that case, much larger GHG reductions would occur. The complexity of the electric systems makes such calculations uncertain, so the results in Table 1 reflect the simple, though possibly conservative, approach of considering only BC Hydro generation. As part of a sensitivity analysis for this project, we also estimated GHG reductions under alternative assumptions for GHG emission factors, see section below for more details.

Energy conservation in new homes provides key benefits in addition to reducing greenhouse gas emissions on Salt Spring Island. Other advantages include reducing the other environmental impacts of energy supply (such as water use ad land development), increased personal comfort from well-insulated, non-drafty homes, plus protection against future escalation in energy prices. Looking at the larger picture, energy conservation helps Salt Spring Island contribute to meeting provincial goals. British Columbia is committed to achieving specific energy conservation targets ("to acquire 50 per cent of BC Hydro's incremental resource needs through conservation by 2020"[1]) and to providing electricity with zero GHG emissions. Energy conservation in new homes contributes directly to the first goal and helps avoid the cost and resource development that would otherwise be needed to meet the second goal through building new hydro-electric or other renewable plants.

[1] Government of British Columbia. February 2007. *The BC Energy Plan: a vision for clean energy leadership*; http://www.energyplan.gov.bc.ca/PDF/BC_Energy_Plan.pdf

Table 1 Summary of Total Energy Savings and Costs for Salt Spring Island (cumulative, covering all new homes built on the Island from 2009 on), various scenarios

Scenario	Fraction of New Houses Affected by Policy	Energy Savings per Year (MWh): 2015	2020	Incremental Costs, annualized, per Year (thousand $) 2015	2020	Incremental Cost per Energy Saved (cents/kWh) 2015	Energy Bill Savings per Year (thousand $) 2015	2020	Annual Reductions in GHG emissions (tonnes per year) 2015	2020
Performance requirement E80	90%	777	1,262	$84	$144	11	$66	$122	18	30
Performance requirement Air Source Heat Pump	100%	2,783	4,522	$323	$554	12	$237	$436	66	108
Information / checklists / incentives (moderate)	5%	139	226	$16	$28	12	$12	$22	3	5
Information / checklists / incentives (strong)	10%	234	380	$27	$46	11	$20	$37	6	9
More attached homes	10%	491	798	net savings			$42	$77	12	19

Note 1 – Greenhouse gas emissions for Salt Spring Island from energy consumption in buildings are estimated at 2,945 tonnes currently.[2]

Note 2 – The incremental costs, energy savings, and greenhouse gas emissions reductions are higher in 2020 than 2015 because the 2020 totals also include the new homes built between 2016 and 2020. The results for 2015 are based on energy savings from 504 new single family homes and 56 new townhouses (63 new single family homes and 7 new townhouses, each from 2009 to 2015). The results for 2020 are based on energy savings from 819 new single family homes and 91 new townhouses (63 new single family homes and 7 new townhouses, each from 2009 to 2020).

Table definitions:

Scenario: represents a policy and the resulting changes in development. The scenarios we analyzed are:

- Performance Requirement for E80: All new residential development on Salt Spring Island must achieve an EnerGuide for New House (EGNH) rating of 80. On June 26, 2008 City of Vancouver Council unanimously approved changes to the Vancouver Building By-law for one and two family dwellings that will likely lead to new dwellings in Vancouver meeting EGNH 80.[3] Note that the requirements of the BC

[2] Sustainability Solutions Group and Holland Barrs Planning Group. Date unknown. *The GHG Implications of Different Settlement Patterns on Saltspring Island.*
[3] City of Vancouver Staff Report. June 8, 2008. Tim Ryce and David Ramslie. http://www.vancouver.ca/ctyclerk/cclerk/20080626/documents/pe5.pdf

Green Building Code will lead to new row houses meeting EGNH 80 so this policy only affects new detached homes.

- Requirement for Air Source Heat Pumps: All new residential development on Salt Spring Island must install air source heat pumps for space heating and cooling. This will affect both attached and detached new homes.
- Information / checklists / incentives: For this scenario, new home-builders are encouraged but not required to build homes with higher energy performance. Incentives for more energy efficient buildings could include density bonus provisions, lowered development cost charges, reduced permit fees, and fast tracking approvals (as outlined in the report *Density Bonus and Other Policy Options for Energy Efficiency*). Sustainability checklists are information tools that allow home-builders to evaluate their plans with a list of sustainability characteristics, evaluate the sustainability of the new home, and identify areas for improvement. A Sustainability Checklist for Salt Spring Island for residential construction is under development. Other examples of information include brochures, having experts available on-site or by hotline to answer questions and provide advice, workshops and websites.
  Due to uncertainty in the type of incentive/information and the impact of the incentive/information on home builders, we have provided two scenarios, moderate and strong, with different assumptions on the fraction of house builders that will improve energy performance.
  - For the moderate scenario, we assume that the incentives and information are sufficient to encourage 5% of new home builders to install heat pumps. We assumed that information and incentives would lead to more heat pumps based on the better economics (shorter payback period) of heat pumps.
  - For the strong scenario, we assume that the incentives and information are sufficient to encourage 10% of new home-builders to install heat pumps.
- More attached homes: Salt Spring Island develops policies to encourage a shift to row house construction rather than single family detached. We assumed that the policy would lead to 10% of new homes being built as row houses (using 5 unit townhouses as basis for energy savings). This is equivalent to about 7 townhouse units per year.

Fraction of new houses affected by policy: This column shows the percentage of new homes that will achieve the higher level of performance dictated in the scenario. Both policies that require (regulate) energy performance standards and policies that provide information/checklists/incentives are intended to increase the number of homes that meet higher energy performance. But the policies that require energy performance standards will affect all new homes, while the information/checklists/incentives are only likely to cause changes in a small fraction of new homes.

Energy Savings: These values are the annual savings in energy consumption on Salt Spring Island, from all new homes affected by the policy.

Incremental costs, annualized: This column shows the additional costs for design, construction and installation to meet the requirements of the scenario. This cost is the total cost for all homes affected by the policy. Costs are annualized, meaning the incremental costs are assumed to be incorporated into the mortgage and paid off over time. We assumed a 25-year term with 5% mortgage rate (excluding inflation).

Incremental cost per energy saved: This value is calculated as the incremental cost divided by the energy saved, on an annual basis. This value can be compared directly to the electricity price to evaluate the cost effectiveness of the efficiency improvement.

Sensitivity Analysis of Greenhouse Gas Emissions Rate and Electricity Prices

The level of reductions of greenhouse gas emissions from reduced electricity consumption depends on the type of electricity generation that is avoided. This avoided generation is uncertain, depending on many factors such as timing and availability of generation resources. For Table 1 we assumed an avoided emission rate of 23.8 tonnes CO2e/GWh (see Key Assumptions for further discussion). To test the importance of this assumption, we also estimate emission reductions assuming an emission rate of 72 tonnes CO2e/GWh. This value is from the updated *Salt Spring Island Energy Strategy*[4], based on values used by BC Hydro in their 2005 Voluntary Challenge and Registry report for 2005. The greenhouse gas emission reductions with alternative avoided emissions rate are reported in Table 2. As with Table 1, the results in Table 2 reflect the GHG savings to be expected from all new homes built on Salt Spring, starting in 2009 up to the year indicated in each column.

Table 2 Annual Reductions in Greenhouse Gas (GHG) emissions, based on alternative avoided emissions rates for electricity

Scenario	Annual Reductions in GHG emissions (tonnes per year)		Annual Reductions in GHG emissions (tonnes per year)	
	2015	2020	2015	2020
Avoided Emissions Rate for Electricity	23.8 tonnes/GWh		72 tonnes/GWh	
Performance requirement E80	18	30	56	91
Performance requirement Air Source Heat Pump	66	108	200	326
Information / checklists / incentives (moderate)	3	5	10	16
Information / checklists / incentives (strong)	6	9	17	27
More attached homes	12	19	35	57

Note: The results for 2015 are based on energy savings from 504 new single family homes and 56 new townhouses (63 new detached homes and 7 new townhouses, each from 2009 to 2015). The results for 2020 are based on energy savings from 819 new detached homes and 91 new townhouses (63 new detached family homes and 7 new townhouses, each year from 2009 to 2020). In the scenario, More attached homes, we still that assume 70 homes are built per year, but assume that the mix is 56 new detached homes and 14 new townhouses.

The cost-effectiveness of this analysis depends on the assumed future electricity prices. The main analysis assumed that electricity rates would increase on average 3% per year (excluding inflation, using the same assumptions as those used in the analysis for the new BC Building Code completed by the Ministry of Energy, Mines and Petroleum

[4] http://www.saltspringenergystrategy.org/docs/SSE_baseline_update.pdf

resources). As a sensitivity, we tested the impact of this assumption by instead assuming that electricity rates increase at 5% per year, excluding inflation. Under this sensitivity assumption, electricity prices were forecast to be 13 cents per kWh in 2020 and home-owners that built to higher efficiency levels or installed heat pumps ended up with net savings (money saved on energy bills exceeded the costs of installing the equipment) in that year.

Analysis per Average Home

Table 3 provides information on the estimated energy savings and incremental costs for the average individual home on Salt Spring Island to meet different levels of energy performance. The incremental cost (annual) refers to the cost of improvements assuming that these costs are incorporated into mortgage-type payments over 25 years. The improvements needed for a home to meet EGNH 80 are likely less than 2% of the average construction cost of new home (based on analysis for City of Vancouver[5]). The cost of installing a heat pump is higher but leads to greater energy bill savings.

The results in Table 3 are at the household level. To determine results across Salt Spring Island (as reported in Tables 1 and 2), the results per household were summed over the number of new houses built each year (assumed to be 70 new households per year, 63 single family and 7 townhouse units per year in most scenarios).

Table 3 Summary of Energy Savings and Costs for individual buildings on Salt Spring Island, various energy performance levels

	Energy Savings (annual kWh)	Incremental Cost (total)	Incremental Cost (annual)	Energy Bill Savings ($)
Single Detached E77	Current BC Green Building Code			
Single Detached E80	1656	$3,083	$212	$112
Single Detached Air Source Heatpump	5565	$11,000	$758	$378
Five Unit Townhouse E77	not permitted under BC Green Buiding Code			
Five Unit Townhouse E80	Current BC Green Building Code			
Five Unit Townhouse Air Source HeatPump	3080	$7,333	$505	$209

Notes: These are average incremental costs based on Lower Mainland estimates for E80 and Vancouver Island values for Air Source Heat Pumps. Energy bill savings are based on the average electricity price between 2008 and 2020 (see assumptions section).

[5] http://www.vancouver.ca/commsvcs/CBOFFICIAL/greenbuildings/greenhomes/#costs

Key Assumptions

This section outlines the key assumptions that we used to estimate the changes in energy, costs, and greenhouse gas emissions for each scenario. We highlight the sources of the assumptions and any important uncertainties that could be discussed through community interactions.

Greenhouse Gas Emission reduction from reduced electricity demand

Salt Spring Island uses almost no fossil fuels for home heating currently and this is expected to continue in the foreseeable future. This reliance on electricity for heating makes assumptions about the greenhouse gas reductions that result from electricity savings particularly important. There are several possible approaches:

- The BC government has mandated that electricity generation have net zero greenhouse gas emissions – starting now for all new generation plants and as of 2016 for all existing generation plants. Therefore, one potential assumption is that changes in electricity consumption in buildings will have no impact on greenhouse gas emissions in the province.
- An alternative assumption is that electricity reductions in British Columbia will allow increased exports of BC's zero-GHG electricity to Alberta or other regions where most of the electricity is produced from fossil fuel-based electricity. In this case the GHG reductions would be quite high.

We expect that the Government of British Columbia will provide some guidance by Fall of 2008 on the accepted GHG emission rate to use for electricity reductions. For this report we have used a value of **23.8 tonnes CO2-equivalent/GWh**. This is the value currently used by Ministry of Energy, Mines and Petroleum Resources.[6] We have also provided GHG emission values based on an alternative GHG emission factor, to provide consistency with the Salt Spring Energy Strategy.

Electricity Costs

The calculated energy cost savings (and therefore the economic payback of the investments) will depend on the cost of electricity. The more expensive the electricity, the more cost-effective energy efficiency improvements become. For the purposes of this analysis we have used the BC Hydro residential rates proposed in the BC Hydro's 2007 Revenue Requirements Application.[7] These rates do not account for the inclining block rate that is currently being considered by the B.C. Utilities Commission, which would have the affect of increasing the cost savings resulting from energy efficiency investments. Sensitivity analysis of this value was also completed and described above.

---

[6] M. Wilson, CAEE co-ordinator, Community Energy Association, personal communication, June 27, 2008

[7] The 2007/2008 rates are 6.37 cents per kilowatt-hour with 7% and 8% increases in 2008 and 2009 respectively. The rates increase at 3% per year thereafter until 2020.

Construction Costs

Table 4 shows the changes to construction that were assumed for a house on Salt Spring Island to reach EGNH rating of 80. The EGNH ratings are performance based, calculated from building design characteristics and performance tests of homes. So a builder on Salt Spring could elect to meet the energy standard using a different mix of construction practices. The elements in Table 4 provide one example that we can use to estimate costs. Appendix A reports the details of the cost calculations that are summarized in Table 4.

Table 4 Incremental Capital Costs to meet EGNH 80 for Single Family Detached dwelling

	Current BC Building Code (~E77)	EnerGuide for New Houses 80 (EGNH 80)
Improved wall insulation and advanced framing[8]	2x6 wood frame construction with 16" stud spacing (Insulation value: RSI 3.85 / R22)	2x6 wood frame construction with 24" stud spacing (Insulation value: RSI 3.85 / R22) Additional cost: $299
Basement insulation	R12 insulation with full wall coverage	R24 insulation with full wall coverage Additional cost: $503
Improved air tightness	3 ACH @ 50 pa (Loose)	1 to 1.5 ACH @ 50 pa (Tight to Somewhat Tight) Additional cost: $154
Heat recover ventilation	Principle exhaust fan	Heat recovery ventilator (HRV), separately ducted Additional cost: $2,127
Total Additional Cost to meet EGNH 80		$3,083

Source: Based on Cooper, K., and Innes Hood Consulting (2004). "Lifecycle Cost Analysis: Energy Standards for New Low Rise Buildings". Report for the Ministry of Energy and Mines.
And Cooper, K., and Innes Hood Consulting (2007). "BC New Low Rise Green Building Code Lifecycle Cost Analysis". Report for the Ministry of Energy, Mines and Petroleum Resources.

The additional cost of installing an air source heat pump is estimated at roughly $11,000 for a detached building. This value was estimated based on two sources. An analysis for retrofitting existing homes for air source heat pumps indicates a cost range of $8,533 to $11,800 with an average of $10,167, based on adding a new heat pump to an existing furnace (in this case electric baseboard heating is assumed), along with upgrading electric service to 200 Amps and modifying duct work. Costs are from a recent analysis of heat pumps on Vancouver Island.[9]

[8] Includes crawlspaces

[9] Salkeld, M. 2007. "Air Source Heat Pump Retrofits in Mid-Vancouver Island" See Table 14.

The other information source was a recent Masters Thesis, that included cost estimates for a new home in Victoria or Vancouver, about 2000 square feet with a heatload of about 12,000 kWh. Costs include ducting, installation, the heating appliance costs, taxes, and hook-up fees. As noted in the following table, installed costs range from $11,040 to $15,600 depending on the efficiency of the heat pump.

Table 5 Estimated Costs for Heating Systems, Victoria, BC

	Total Costs	Incremental Costs to Baseboard Heating
Electric Baseboard Heating	$5,454	$0
Electric Furnace	$10,470	$5,016
Air Source heat pump (ASHP) – HSPF 9.9	$15,600	$10,146
ASHP – HSPF 8	$12,419	$6,965
ASHP – HSPF 7.3	$11,040	$5,586

From Gorecki, K. (2006) "The Social Costs of New Construction Residential Space Heating in British Columbia" Project for Master of Public Policy, Simon Fraser University.

Note: HSPF is the Heating Seasonal Performance Factor, which is the total heating output of a heat pump during its normal annual heating usage period divided by the total electric power input for the same period. It is the measurement of how efficiently residential heat pumps will operate in their heating mode over an entire normal heating season. The higher the HSPF, the more efficient the system.

Costs for air source heat pumps for attached homes were not readily available from the sources checked. We made a rough estimate of $7,333 based on scaling the costs for attached homes by assumed size of homes. We did not include an analysis of ductless (mini-split) heat pumps, which may be more applicable to retrofit situations, but also for townhouses. The costs of the ductless heat pumps appear to be in the range of $6,000 to $7,000.[10]

[10] US Department of Energy. *Ductless, Mini-Split Heat Pumps.* A Consumer's Guide to Energy Efficiency and Renewable Energy. Accessed July 30, 2008. http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12630

The following tables summarize all key assumptions for the analysis.

Table 6 Energy savings and incremental construction/installation costs

Name	Value	Units	Notes	Source
Energy consumption - Electricity use in new house designed to meet BC Green Building Code 2008, detached dwelling	83,678	MJ/year	Value based on estimates for Lower Mainland	Cooper, K., and Innes Hood Consulting (2007). "BC New Low Rise Green Building Code Lifecycle Cost Analysis". Report
Energy consumption - Electricity use in new house that is designed to meet EnerGuide for New Houses 80, detached dwelling	77,717	MJ/year	Value based on estimates for Lower Mainland	Cooper, K., and Innes Hood Consulting (2007). "BC New Low Rise Green Building Code Lifecycle Cost Analysis". Report
Incremental Capital Costs to neet EGNH 80, detache dwelling	3,083	$	Value based on estimates for Lower Mainland	Cooper, K., and Innes Hood Consulting (2007). "BC New Low Rise Green Building Code Lifecycle Cost Analysis". Report
Energy consumption - Electricity use in new house with air source heatpump (insulation and windows meet BC code as of 2008), detached dwelling	63,645	MJ/year	50% savings in heating electricity (roughly based on Sakeld 2007) from heating load of 40,067 MJ/year (Gorecki 2006)	Sakeld, M. 2007. "Air Source Heat Pump Retrofits in Mid-Vancouver Island" Gorecki, K. (2006) "The Social Costs of New Construction Residential Space Heating in British Columbia"
Costs of Air Source Heat Pump	11,000	$	based on Salkeld 2007, incremental cost of air source heat pump installation relative to baseboard	Sakeld, M. 2007. "Air Source Heat Pump Retrofits in Mid-Vancouver Island"

Table 7 Housing characteristics

Name	Value	Units	Notes	Source
Annual # of new housing units - total	70			Average number of new units built per year, 2004 - 2007. Information supplied by CRD Building Inspection Services
Fraction of Buildings that are Single Family	90%			same source as above
Fraction of Buildings that are Attached (row/townhouse)	10%			same source as above
average size of new:				
single family detached	234	m2		average size of new units built over period 2006-2007. Information supplied by CRD Building Inspection Services.
row house unit	144	m2		
Mortgage term	25	years		assumption
Mortgage rate	5%	annual	average (excluding inflation) for BC 2001-2007	BC Stats, June 24, 2008, Selected Economic Statistics For British Columbia
Residential Electricity rate 2007	6.37	cents/kWh		BC Hydro Revenue Requirements Application 2007,
Residential Electricity rate increase 08/09	7%	% per year	based on rate application to BCUC	BC Hydro Revenue Requirements Application 2007,
Residential Electricity rate increase 09/10	8%	% per year	based on rate application to BCUC	BC Hydro Revenue Requirements Application 2007,
Increase in electricity prices (excluding inflation)	3%	%/year	From BC MEMPR analysis for BC Building Code	Cooper, K., and Innes Hood Consulting (2007). "BC New Low Rise Green Building Code Lifecycle Cost Analysis". Report

General Parameters

Parameter	Value
sq feet to m2	0.0929
GJ to kWh	277.8
MJ to kWh	0.2778
GWh to GJ	3600.0
kWh to GJ	0.0036

Avoided Carbon Loss through Forest Protection

New development in Salt Spring Island on undeveloped forest land, or extensions of buildings to areas of the property that were previously forested, will lead to release of carbon that had been stored in trees, other plants, understory and the soil. The amount of carbon released depends on several key attributes:

1. What the current forest composition is within the various strata of the forest and how long the forest has remained undisturbed.
2. The depth and composition of the potentially disturbed soil layers.
3. The overall productivity of the site (net primary production).
4. How the removed wood is used.[11]

This section provides rough estimates of the carbon that would be released from a simple disturbance (i.e. residential development) on a site that could be avoided by alternative development strategies. For example, homeowners can limit the amount of land that is used for roads and driveways by placing homes side by side within a site or sharing road requirements between several sites. Policies that encourage tree retention and limit the amount of land that is permanently changed from natural conditions, will help avoid the loss of stored carbon. This preliminary analysis addresses the first three attributes listed above. Further analysis will be required to address the impacts of how the removed wood is used.

We consider only four species of trees and plants, Douglas-fir (*Pseudotsuga menziesii),* Western Hemlock (T*suga Heterophylla)*, Red Alder *(Alnus rubra*)*,* and natural grassland. These are fairly representative of the growth on the island. Without sample plots from the actual sites of concern we assumed that the land represents a typical forested stand in the Coastal Western Hemlock biogeoclimatic zone with rates of decomposition, respiration and precipitation rates are representative of this zone. For the three tree species, we show estimates for sites with either good or moderate quality.

Since the trees on different sites will be at different ages, Table 8 depicts the carbon storage base on current stand age, species, and quality of site to show representative amounts of carbon storage that could be expected on sites.

[11] If the trees that are removed are used in products with long lives (homes, infrastructure, some furniture uses), the carbon stored in the biomass could remain sequestered from the atmosphere for a long time.

Table 8 Carbon Storage in Non-soil sources (Live Standing Trees, Dead Standing Trees, Understory, Down Dead Wood, Forest Floor) (tonnes CO_2e / 100 m^2)

Age (years) → Species and site quality ↓	10	20	40	80
Douglas-fir – good quality	3.30	3.70	6.84	11.45
Douglas-fir – medium quality	1.34	1.50	2.77	4.64
Western Hemlock – good quality	3.24	3.33	6.36	12.37
Western Hemlock – medium quality	0.91	0.93	1.78	3.46
Red Alder – good quality	2.74	3.12	4.66	5.97
Red Alder – medium quality	1.13	1.28	1.92	2.46
No trees / grasslands	Relatively low amounts in non-soil sources – see table below for soil estimates			

The amount of carbon stored in the soil is dependent on the type of forest, but not on the age of trees, and is summarized in the table below.

Table 9. Carbon Storage in soils (tonnes CO_2e / 100 m^2)

Species ↓	Carbon content (tonnes CO_2e/ 100m^2)
Douglas-fir*	2.89
Western Hemlock*	4.20
Red Alder*	4.19
No trees / grasslands**	0.73 – 1.83
Mineral soils***	23.2- 25.1

*The measures of carbon for Douglas-fir, Western Hemlock and Red Alder represents soil organic carbon.

**High uncertainty in these values for Salt Spring Island context.

*** The carbon measures for Douglas-fir, Western Hemlock, Red Alder and Grasslands represents a measure of soil carbon to a depth of 1 metre. After this depth, the mineral soil measure should be applied. This measure can be applied across all forest types as it captures a measure of the mineral soil carbon for the Pacific Cordillera biogeoclimatic region.

When applying the estimates provided above, it should be recognized that these values are static measures of forest above and below ground carbon and do not take into account daily, or annual fluxes in carbon stocks.

Further research would be needed to refine the above estimates to be more reflective of specific conditions on Salt Spring Island. These refinements would include a more accurate assessment of the carbon storage potential on the island and also an assessment of the potential risk of carbon loss due to human and natural disturbances.

CAUTION Comparing greenhouse gas emission reductions from energy efficiency improvements with carbon storage in biomass on residential sites. Readers need to be cautious in comparing the values in Table 1 with Tables 8 and 9, especially in terms of evaluating which policy options to pursue. The carbon storage values are provided for a single patch of land, while the energy efficiency estimates are based on changes throughout the community. Also the greenhouse gas reductions from energy efficiency values refer to annual estimates (these values could be summed over the lifetimes of the new homes), while the carbon storage values refer to a single point in time but the carbon has been stored over years. However homeowners and policy-makers on Salt Spring Island are not forced to make this tradeoff. Both opportunities (increasing energy efficiency and conserving biomass) can be pursued simultaneously. Also note that the carbon stored from forest retention cannot be considered as GHG reductions relative to Salt Spring Island's base case, unless the base case also includes estimates of the carbon storage changes due to land use changes.

Additional Information on Assumptions

We were unable to find a single source of information on the carbon stored in biomass on Salt Spring Island. The estimates in the table above are based on key assumptions on carbon storage from the following three data sources:

- US Department of Agriculture for Coastal Douglas-fir forests in Washington State forests – for estimates of carbon storage in good quality sites of Douglas-fir, Western Hemlock and Red Alder;
- *Private Woodland Planner* software, developed by Enfor Consultants Ltd – for estimates of difference in wood volume between good and medium quality sites for the same three tree species; and
- Land Trust Alliance of British Columbia report *Mitigating and Adapting to Climate Change Through the Conservation of Nature* (Wilson and Hebda 2008)

Estimates for such stands were not readily available from the Canadian Forest Service or the BC Ministry of Forests but review by professionals at the Canadian Forest Service confirmed that the Washington State data are a reasonable estimate for Salt Spring Island.

The US Department of Agriculture (USDA) data provided carbon storage by species and age. We assumed that the USDA data pertained to good quality sites, but were not able to obtain data for lower quality sites from the USDA. The Private Woodland Planner (PWP) software provides estimates of carbon stored by quality of site. However the PWP software uses a very simple estimate for carbon storage. For all species, age and quality of trees, "PWP uses a rough correlation of $1m^3$ [merchantable bole volume] = 1 tonne CO_2 sequestered."[12] So we did not use PWP for direct estimate of carbon storage, assuming the detail in the USDA estimates would be more appropriate. But, we used PWP to estimate the ratio of volume of merchantable bole volume of good to medium quality sites (PWP did not provide volume estimates for sites that were not at least medium quality). This ratio was used, along with the USDA carbon estimates to calculate the carbon stored at medium quality sites. PWP did not provide any information on carbon stored in soils.

For non-treed areas we relied on the Land Trust Alliance (LTA) report. Although this report was produced for British Columbia, the data in the report for grasslands appear to

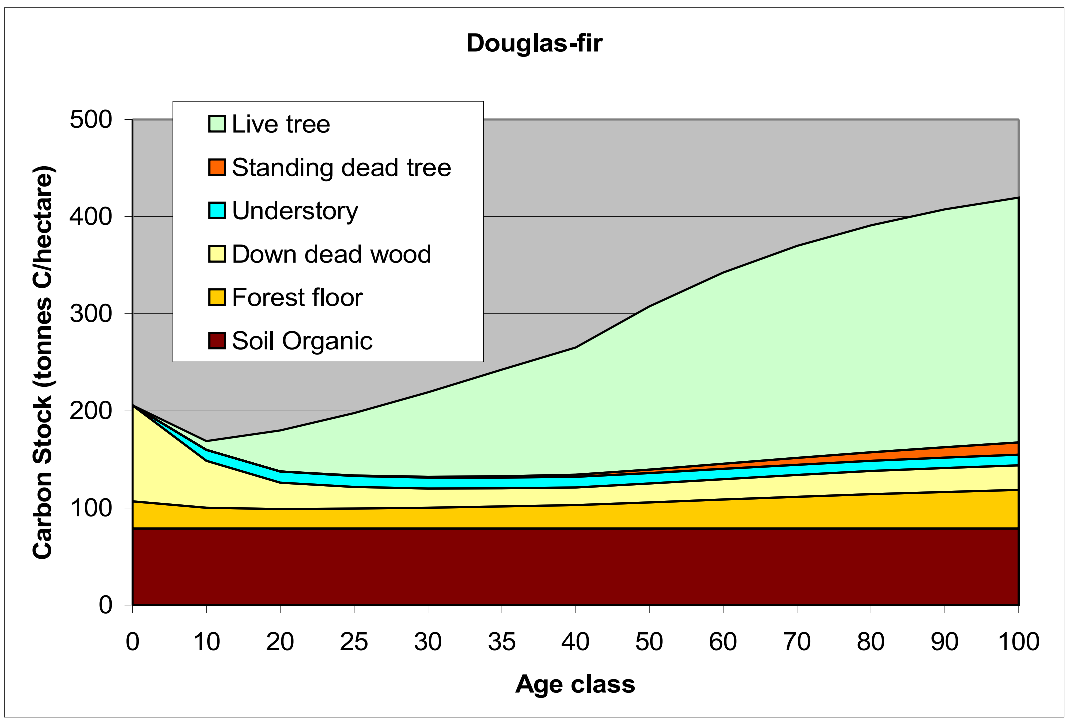
[12] Enfor Consultants Ltd. May 2007. *Private Woodland Planner User Guide Version 2.0.* Page 29.

be obtained from estimates for the Great Plains of the United States. These values are reported in the tables above.

Forest Carbon Storage – carbon stored in forests can be grouped into six categories: live tree, standing dead tree, understory, down dead wood, forest floor, and soil organic layers. What is important to note is that soil carbon was only captured in this analysis as it relates to soil organic carbon. While soil carbon comprises nearly 70% of the total carbon budget in a forest it was omitted in this analysis as the soil carbon below the organic carbon layers are not expected to be impacted.[13]

As a stand of trees ages the stores of carbon in each category will increase or decrease depending on the age class structure of the stand and the accumulation of understory in the stands. For example, between the ages of 5 and 10 years a Douglas-fir stand will typically increase its carbon storage in live trees by six times as the trees grow but will experience a 30% loss in carbon stored in down dead wood, as that carbon is oxidized through the decay process. The exception to this is soil organic, where carbon storage amounts stay relatively constant over time.

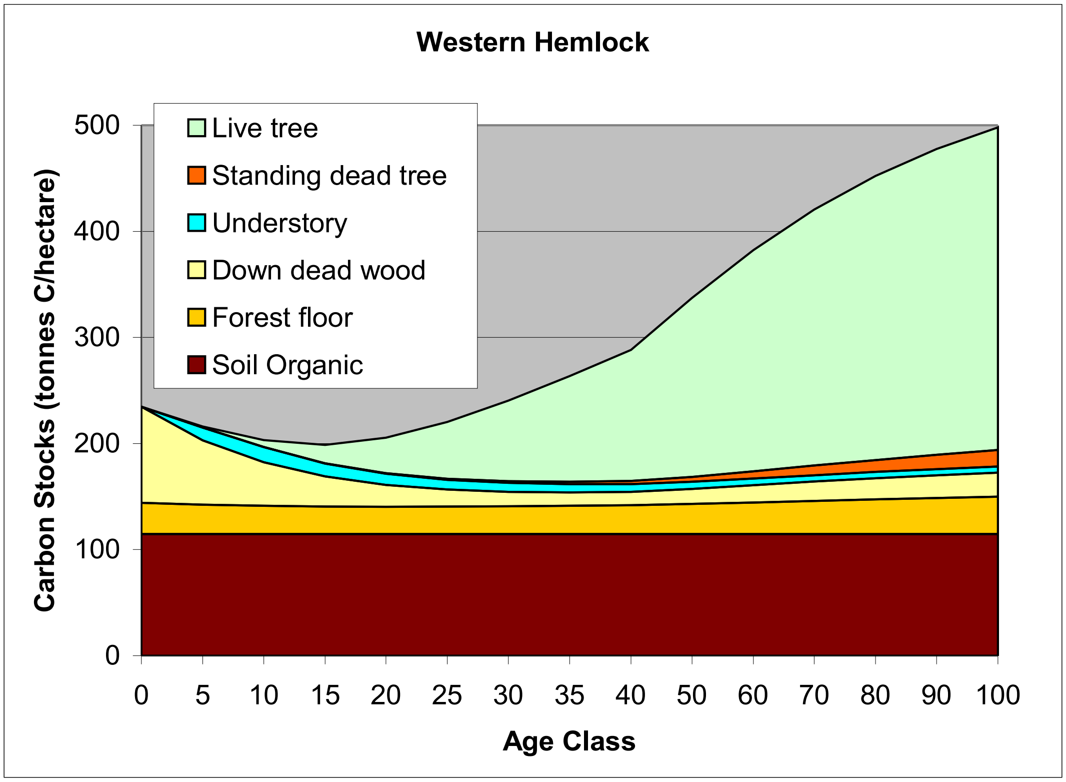
The following figures show the carbon storage estimates for Douglas-fir, Western Hemlock and Red Alder, indicating the relationships between age of stand and the carbon storage. These figures also illustrate the differences in carbon storage between the different tree species. All figures represent good quality sites.



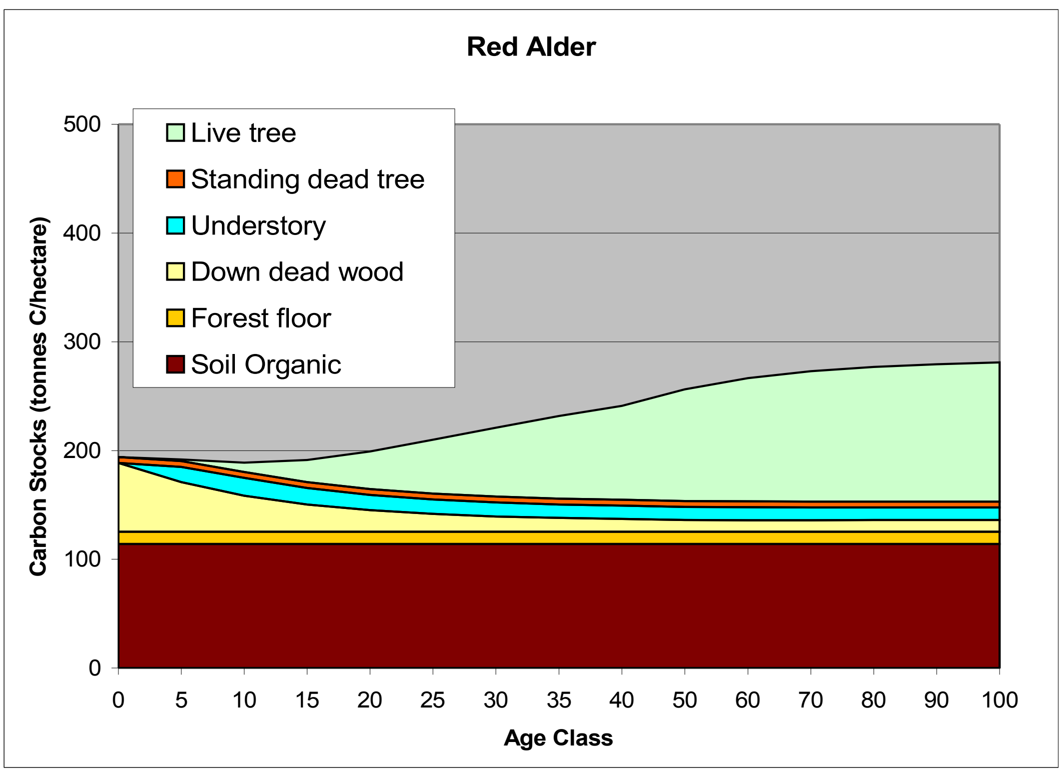
Source: USDA Forest Service. COLE 1605 (b) Report for Washington. (COLE Development Group, Durham, N.C.: June 2008)

---

[13] Z. Li, M.J. Apps, W.A. Kurz, S.J. Buekema."Below ground biomass dynamics in the Carbon Budget Model of the Canadian Forest Sector: recent improvements and implications for estimating NPP and NEP" *Canadian Journal of Forest Research.* Vol. 33, issue 1 (2003): 126-136..



Source: USDA Forest Service. COLE 1605 (b) Report for Washington. (COLE Development Group, Durham, N.C.: June 2008)



Source: USDA Forest Service. COLE 1605 (b) Report for Washington. (COLE Development Group, Durham, N.C.: June 2008)

References

BC Stats (2008). June 24, 2008, *Selected Economic Statistics For British Columbia.*

Cooper, K., and Innes Hood Consulting (2004). *Lifecycle Cost Analysis: Energy Standards for New Low Rise Buildings*. Report for the Ministry of Energy and Mines.

Cooper, K., and Innes Hood Consulting (2007). *BC New Low Rise Green Building Code Lifecycle Cost Analysis*. Report for the Ministry of Energy, Mines and Petroleum Resources.

Curran, Deborah. July 31, 2008. *Density Bonus and Other Policy Options for Energy Efficiency.* Prepared for Capital Regional District and Islands Trust for Community Action on Energy and Emissions – Gold Program.

Enfor Consultants Ltd. (in association with Crane Management Consultants) *Private Woodlot Planner* Software and Users Guide. Accessed June 2008.

Gorecki, K. (2006) "The Social Costs of New Construction Residential Space Heating in British Columbia" Masters Thesis, Simon Fraser University.

Ryce, Tim and David Ramslie. City of Vancouver Staff Report. June 8, 2008. http://www.vancouver.ca/ctyclerk/cclerk/20080626/documents/pe5.pdf

Salkeld, M. 2007. *Air Source Heat Pump Retrofits in Mid-Vancouver Island*. Report for the Ministry of Energy, Mines and Petroleum Resources.

Siltanen, R.M., Apps, M.J., Zoltai, S.C., Mair, R.M. and Strong, W.L. "A soil profile and organic carbon data base for Canadian forest and tundra mineral soils." Canadian Forest Service, Northern Forestry Centre(1997).

Sustainability Solutions Group and Holland Barrs Planning Group. Date unknown. *The GHG Implications of Different Settlement Patterns on Saltspring Island.*

Wilson, Sarah and Richard Hebda. 2008. *Mitigating and Adapting to Climate Change Through the Conservation of Nature.* Prepared for Land Trust Alliance of British Columbia.

Appendix A Costs of Energy Performance Improvements for Single Family Detached Homes

Improved wall insulation and advanced framing

		framing	insulation	total	
Green Building Code	2x6 @ 16"OC, RSI 3.5 (R20)	30.84	6.58	37.42	$/m2
EGNH80	2x6 @ 24"OC, adv. framing; RSI 3.85 (R22)	27.55	11.20	38.75	$/m2
incremental cost		-3.29	4.62	1.33	$/m2
Area of walls		*Height*	*Perimeter*	*Area*	
	Main	2.44	42.00	102.48	m/m2
	Second	2.44	38.75	94.55	m/m2
	Crawlspace	1.3	22.00	28.6	m/m2
	Total			225.63	m2
Total cost				**299.19**	$

Basement Insulation

Green Building Code	2x4 @ 24" OC, RSI 2.1 batt full height			5.19	$/m2
EGNH80	RSI 4.9 batt @ full depth below grade; gyproc			11.31	$/m2
incremental cost				6.12	$/m2
Area of walls		*Height*	*Perimeter*	*Area*	
	Basement	2.74	30.00	82.2	m/m2
Total cost				**503.06**	$

Improved air tightness

Air Tightness	incremental cost	0.78	$/m2
Area of walls	see above (Main and 2nd)	197.03	m2
Total cost		**153.68**	$

Source: Cooper, K., and Innes Hood Consulting (2004). "Lifecycle Cost Analysis: Energy Standards for New Low Rise Buildings". Report for the Ministry of Energy and Mines.
And Cooper, K., and Innes Hood Consulting (2007). "BC New Low Rise Green Building Code Lifecycle Cost Analysis". Report for the Ministry of Energy, Mines and Petroleum Resources.