Comparisons to other buildings in BC
Eco-Sense and Net Zero Energy

Introduction

Eco-Sense is an example of an emerging trend in housing that integrates sustainable energy and water systems with low carbon construction materials and methods. Located in the Highlands of Greater Victoria, this project began as a challenge to build a home as sustainable as the BC Building Code would allow. What developed was the creation of the first legal, seismically engineered load bearing high occupancy cob building in North America. Based on the earthen architectural concepts that have been utilized for millennia throughout the world, this home incorporated the science of modern structural engineering while surpassing the standards as set out in the BC Building Code. Sustainable systems integrated into this house include net zero solar PV (electricity), solar thermal (hot water), wood pyrolysis (or gasification) for winter heating, living roofs, rainwater harvesting, grey water systems, waterless no-flush composting toilet, and productive food gardens for the occupants.

The purpose of the comparative research was to document the performance of this historically proven building method and compare with today's technology and housing standards. Specific research areas include heating, cooling, moisture control, and temperature moderation while providing a living space that was equal to if not better than current housing standards.

Comparison to conventional

A critical area of the research is the comparison of the Eco-Sense home with that of the average typical detached residence in British Columbia. The 2008 year represents the most recent data available from the Natural Resources Canada's (NRCan) National Energy Use Database (NEUD): Comprehensive Energy Use Data[1].

Review of the Climatic variables - Insolation

Important Note: Solar insolation was abnormally low for the region for the year of study. The average yearly insolation is 1,242 kWhr/m^2; the measured value was 1,050 kWhr/m^2; this represents a 192 kWhr/m^2 reduction from the average, or approximately 15% less available sunshine. This equates to missing approx. 2 months of solar insolation. (Note that the months that showed the largest actual decrease were the shoulder seasons (spring and fall), when reliance on the solar insolation for both passive and active solar heating is greatest.

Actual Monthly Insolation (kWh/m2)	Average Insolation for Lat/Log from NASA (kWhr/m2/day)	Average Monthly Insolation for Lat/Log from NASA (kWhr/m2)	Average difference from expected

Jan	21.54	1.04	32.24	-33.2%
Feb	35.60	1.91	53.48	-33.4%
Mar	62.12	2.93	90.83	-31.6%
Apr	102.76	4.2	126.00	-18.4%
May	137.39	5.17	160.27	-14.3%
Jun	172.68	5.67	170.10	1.5%
Jul	193.74	6.08	188.48	2.8%
Aug	147.61	5.4	167.40	-11.8%
Sep	83.13	4.07	122.10	-31.9%
Oct	56.59	2.25	69.75	-18.9%
Nov	20.88	1.18	35.40	-41.0%
Dec	16.79	0.86	26.66	-37.0%
	1050.82		1242.71	-15.4%

A year with a 15% overall decrease of insolation results in higher energy inputs for heating across this region, and is demonstrated in the difference between the average Heating Degree Days (HDD) for the area (2902 HDD[3]), and the measured HDD (3307 HDD[4]). This notable difference translates into a 14% increase in HDD for the time period of study.

Energy Intensity

In BC the average single detached residence has a footprint size of 187.7 m^2, inhabited by 2.5 occupants[5]. The Eco-Sense house has an area of 200 m2, with an average of 5 occupants[6]. The average space per BC resident is 59.1 m^2; whereas at Eco-Sense it is 40 m^2, a decrease in footprint per occupant of 32% from the BC normal.

When the measured energy data for heating is adjusted to account for the actual low insolation period (based on the difference in HDD), the adjusted energy intensity numbers show how the house would perform in an average year. This method would give a more accurate comparison. See third column.

Overall energy usage shows Eco-Sense consumed 94.7% of that of a typical average residence in BC. The make up of energy consumption shows a drastically decreased use of electricity, using only 18.3% of the average, but is accounted for with the use of wood fuel where the numbers are reversed. Due to this drastically different energy make-up between the "Average" and Eco-Sense, we must drill down and look at the energy intensity of the home, the area of the home and relate it to the residents.

Eco-Sense is approximately 13 m^2 larger in living area than the BC average, with a total area of 200.67 m^2. The energy intensity per square meter for Eco-Sense is 150.43 kWhr/m^2 (or 0.54 GJ/m^2) vs. 169.44 kWhr/m^2 (0.61 GJ/m^2); this is a difference of 11.2% less, or Eco-sense has an energy footprint that is 88.8% of the average.

Energy intensity measurements take into account both the operations of the structure and the lifestyles of the occupants and therefore the energy footprints of individuals are included. (Examples of lifestyle energy footprints include length of hot showers, size and number of TV's, number of household appliances, type of cooking, etc)
The residents of Eco-Sense have an energy footprint of 6037 kWhrs/year as compared to the average BC resident at 12744 kWhrs/year; a difference of 52.6% less energy per person, then that of the average resident in a similar home.

When the energy footprint from above is applied to the space they inhabit, the results show that energy intensity/person/m^2 is more substantial; that Eco-sense has an intensity of 30.09 kWhrs/person/m^2 versus the BC average of 67.78 kWhrs/person/m^2. Therefore on a per person /m^2 basis, the individual energy intensity is 55.6% less than that of the BC average.

The Eco-Sense results would have been quite different if the data were collected in an average insolation year. See table.

	BC Avg Single Detached Residence (NRCAN NEUD 2008)	Actual Eco-Sense (kWhr)	Adjusted Eco-Sense (kWhr)	% Difference from average
Energy Use by Energy Source (kWhr)				
Electricity	12731.12	2324.85	2324.85	
Natural Gas – LP Gas	16235.09	1263.00[7]	1263.00[8]	
Heating Oil	204.40	0	0	
Other2 (inclusive of Solar Thermal)	262.80	5709.29	5709.29	
Wood	2452.78	20890.7	17965.46	
Total Energy (kWhr)	31886.19	30187.84	27262.60	
Energy Source Breakdown (%)				
Electricity	39.9%	7.6%	8.5%	
Natural Gas	50.9%	4.2%	4.6%	
Heating Oil	0.6%	0.0%	0.0%	
Other2 (including solar thermal)	0.8%	18.9%	20.9%	
Wood	7.7%	69.2%	65.9%	
Average Floor Space (m^2)	187.74	200.67	200.67	
Energy Intensity (GJ/m^2)	0.61	0.54	.49	20% Less
Energy Intensity (GJ/household)	114.70	108.7	98.15	14.4% Less
Energy intensity/person/m^2 (per detached residence)	0.24	0.11	.10	58.3% Less
Energy intensity/person/detached residence	45.88	21.70	19.63	57.2% Less
Energy Intensity (kWhr/m^2)	169.44	150.43	135.86	19.8% Less
Energy Intensity (kWhr/household)	31861.11	30187.84	27262.60	14.4% Less
Energy intensity per person m^2 (per detached residence) (kWhr/m2)	67.78	30.09	27.17	60% Less
Energy intensity per person per detached residence (kWhr)	12744.44	6037.57	5452.55	57.2% Less

Summary of Energy Intensity

A more efficient use of space produces a home that uses less energy across a wide range of indices, where the energy intensity of the building itself is 11.2% less, where the residents use 52.6% less than the average BC resident, and where the energy intensity per person/m2 is 55.6% less than that of the average BC resident's footprint intensity. These comparisons are between an average house in an average insolation year and it has been clearly demonstrated that the period of research was not a normal year. See table.

This demonstrates an exceptional divergence from normal values in the energy profile of the home and the occupants.

Space Heating

In an average year the average residence in BC uses 19,739 kWhrs of energy to heat its space resulting in energy intensity of 105 kWhrs/m^2; for comparison, Eco-Sense, in a sunlight deficient year used 24,948 kWhrs for an intensity of 124 kWhrs/m^2. As noted earlier the test year observed a 15% decrease in solar insolation and a subsequent increase in HDD by 14%. If the research study was conducted in an average year the adjusted space heating would have been 21,719 kWhr for an intensity of 108 kWhrs/m^2. This demonstrates that the envelope is performing very similar, with an increased energy intensity usage of 2.9%. As noted earlier, the recorded insolation deficiency came in the Spring and Fall when the Eco-Sense home was very dependant on solar gain for both passive and active solar heating.

Average Single Detached 2008 (kWhr)	Average Space Heating intensity (kWhr/m2)	Eco-Sense Space Heating (wWhr)	Eco-Sense Space Heating Intensity (kWhr/m2)	Adjusted Eco-Sense Space Heating (kWhr)	Adjusted Eco-Sense Space Heating Intensity (kWhr/m2)
19739.07	105.14	24948.72	121.99	21719.16	108.21

Since the completion of the house, much has been learned that would greatly increase the thermal performance of the earthen home. Such improvements would include:

1. The detailing of the insulation of the concrete foundation with the addition of better thermal breaks;
2. The use of light clay (wood chip and clay) infill for the upstairs exterior walls instead of pumice cob.
3. Addition of a Larson truss on the exterior north load bearing cob wall filled with a light clay infill and then plastered.
4. Utilizing a summer heat dump under the earthen slab for storing surplus solar energy to draw upon in winter heating months.

Water Heating

Water heating is generally controlled by the usage patterns of the residents. The BC average energy per person per BC household is 2148.64 kWhr; the Eco-Sense average is 330.13kWhrs. This is a dramatically different usage pattern than that of the average BC resident wherein Eco-Sense on a per person basis uses 84.6% less energy to heat its domestic hot water on a per person basis. Of all the heated water, the majority is from solar thermal collection.

2008 BC Average	2008 BC Average	Eco-Sense	Eco-Sense
Total usage/household (kWhrs)	Intensity / m2 (kWhr/m2)	Total household usage (kWhr)	Intensity / m2 (kWhr/m2)
	Intensity		
	0.00		0.00
0.00	0.00		0.00
5371.61	35.96	1650.63	8.22

Avg usage /Person (kWhr)	2148.64	Usage / person (kWhr)	330.13

Carbon Analysis

Average BC annual GHGe for operations for a detached BC household in 2008 was 3.15 metric tons, (NRCAN NEUD: Table 34: Single Detached Secondary Energy Use and GHG Emissions by Energy Source). Note that the electricity generation is excluded from the 2008 BC average GHGe however electricity is included in the Eco-Sense calculations. This skews the figures showing that the Eco-Sense values are over estimates

Average construction GHG based on a house the same size using the Build Carbon Neutral carbon calculator 65 metric tons[9]. (This document is attached in Appendices)
Average lifespan of conventional home is 40 years.
Overall carbon footprint /year for the average home is 40 years x 3.15 = 126, plus 65 tons for a total of 191 tons of GHGe/carbon emitted over the life span which works out to be 4.78 metric tons per year.

Eco-Sense GHG carbon from construction derived from the Environmental Agency and Green Footprint calculators (calculations are attached in appendices) estimates the carbon footprint of construction at a zero carbon footprint.

For operations, the Eco-Sense average GHGe from wood is based on 17965 kWhrs of energy. There is 5.49 kWhr/kg of energy; therefore there is 3272 kg of wood used to produce 17965 kWhrs – with a conversion factor of 1.779 this equates to 5821 kg of

CO_2e with a allowance for a half charge to be accounted for re-uptake, this leaves 2910 kg (2.91 tons)[10] of yearly emissions.

In addition there is 266 ltrs of propane consumed, which is equivalent to 400 kg CO_2 (0.4 ton). Thus the annual carbon footprint emitted from operations is 3.79 tons.

Average Lifespan 500 - Overall carbon footprint per year over lifespan of 500 years is 500 x 3.79 = 1895 tons of carbon, which is 3.79 tons per year.
Therefore the overall carbon footprint of the eco-sense home is 1 ton lower than that of a conventional house of the same size over its lifespan.
On a per person basis (4.78/2.5) 1.91 tons is emitted per BC resident on average, whereas at Eco-Sense 0.66 tons are emitted per person.

	Average House/year (2.5 people)	Eco-Sense House/year (5 people)
GHGe operations	3.15	3.31
GHGe construction	1.625	0
tGHGe	4.78	3.31
tGHGe perperson	1.91	0.66

Affordability

Stats Canada data from 2009 Mortgage loan approvals shows new residential construction and existing residential properties, by province and territory: Alberta, British Columbia, Yukon, Northwest Territories[11] show that the average new construction cost for a single detached home in BC was \$441,197; as the average size is 147.7 m^2, this comes to a cost /m^2 of \$2987/m^2 (or \$277/ft^2). For comparison, the Eco-Sense cost of construction was \$1593/m^2 (or \$148/ft^2). The monthly costs for energy are drastically different as the costs of wood per year do not exceed \$550 (average of \$45/month). Other costs are negligible, such as minor charges like an Eco Fee on the BC Hydro statement.

Compared to the average new construction, Eco-Sense was 46.5% less expensive to build with the added benefit of minimal \$45 in additional costs to service supplemental energy that is not generated onsite.

If the Eco-Sense homeowners were to invest the \$40,000 to remove all requirements for fossil and wood fuels (i.e. install a heat pump and more solar panels), the costs would increase an additional amount of \$200/m2 for a total of \$1793/m2 (or \$167/ft2). Still a reasonable cost in relation to today's construction costs.

Lessons learned

1. Higher density living arrangements within a single family home promote decreased energy intensity overall.
2. Equal emphasis should be placed on occupant lifestyle **and** building envelope performance in regards to energy performance. Cannot separate the lifestyle of the inhabitants from the performance of the building.
3. Equal emphasis should be placed on embodied energy for construction **and** operations over the expected lifespan of the building.
4. The earthen architectural method utilized for Eco-Sense requires a very similar amount of energy to heat compared to the average house in an average year.
   a. However, it has been demonstrated the importance of building such an earthen home in the full sun
   b. Essential to incorporate passive solar features into the design.
   c. Also beneficial to increase thermal performance of north walls.
5. Green House Gas reduction possibilities for the Eco-Sense home include:
   a. tGHGe's for space heating could be reduced by installing an air to water heat pump instead of the wood gasification boiler. A heat pump (with a COP of 4.5) could reduce the energy intensity of the space heating from the 20890 kWhrs down to 4700 kWhrs, but would require 200% more solar panels (thirty-two 170 Watt) with a current value of $16,000.
   b. tGHGe's from cooking could be reduced by removing the propane ranges and replacing with electric. This would require an addition of 50% more solar panels (eight 170 Watt) at a cost of $4,000.
6. Eco-Sense could be an affordable net zero energy home:
   a. Addition of forty 170 Watt solar panels would decrease the annual carbon emissions of the home to zero, and thus make it truly a net zero energy home that uses no carbon emitting sources of energy.
   b. Total costs of these additions would equate to approximately $40,000 (heat pump, solar panels, mounting hardware, additional inverter, and professional install). Total cost per square foot would increase to $164/ ft^2.
7. Local Resiliency: Noted observation that reliance on technology may decrease resiliency in the face of technological failure, and lower tech solutions are easier to repair and less costly to maintain.
8. Climate change: If the weather anomaly experienced for the duration of this research (June 15, 2010 to June 16, 2011) is any indication of insolation patterns to be expected in the future, it will become increasingly important to optimize passive solar design and size active solar installations appropriately and not to base these on past normal's.

Appendix of Documents

Solar Insolation Data

Solar insolation data was collected from Uvic Weatherstaon Network's three closest weather stations, Eagle View Elemetary, Cal Revelle Nature Sanctuary, and East Highlands Firehall. Due to shading from trees at Cal Revelle and East Highlands, the data was weighted more heavily on Eagle View Elementary.

Table 1 – Daily Insolation

	Daily Insolation	W/m2	
1	06/20/10	4137.96	
2	06/21/10	3998.24	
3	06/22/10	6541.07	
4	06/23/10	5955.00	
5	06/24/10	5683.94	
6	06/25/10	6732.44	
7	06/26/10	6632.95	39681.59
1	06/27/10	2546.97	
2	06/28/10	3910.32	
3	06/29/10	5178.84	
4	06/30/10	5581.79	
5	07/01/10	2669.24	
6	07/02/10	4296.75	
7	07/03/10	5154.00	29337.91
1	07/04/10	4737.56	
2	07/05/10	4422.63	
3	07/06/10	7263.84	
4	07/07/10	7332.26	
5	07/08/10	7192.80	
6	07/09/10	6437.72	
7	07/10/10	7024.18	44411.00
1	07/11/10	7072.10	
2	07/12/10	6098.60	
3	07/13/10	6605.04	
4	07/14/10	7016.18	
5	07/15/10	7009.94	
6	07/16/10	6947.16	
7	07/17/10	6912.24	47661.25
1	07/18/10	6884.76	
2	07/19/10	6287.53	
3	07/20/10	6025.81	
4	07/21/10	6554.02	
5	07/22/10	5723.10	
6	07/23/10	6692.80	
7	07/24/10	6715.86	44883.88
1	07/25/10	6714.87	
2	07/26/10	6540.25	
3	07/27/10	6523.75	
4	07/28/10	6545.14	
5	07/29/10	6257.86	
6	07/30/10	6458.39	
7	07/31/10	5626.72	44666.98
1	08/01/10	4763.92	
2	08/02/10	4910.13	
3	08/03/10	5000.02	
4	08/04/10	5567.35	
5	08/05/10	4950.88	
6	08/06/10	5685.98	
7	08/07/10	1034.09	31912.36
1	08/08/10	5299.30	
2	08/09/10	2362.00	
3	08/10/10	4302.20	
4	08/11/10	5886.99	
5	08/12/10	5843.38	
6	08/13/10	6040.45	
7	08/14/10	6086.96	35821.28
1	08/15/10	5946.09	
2	08/16/10	5573.68	
3	08/17/10	5562.50	
4	08/18/10	5518.98	
5	08/19/10	3653.78	
6	08/20/10	4554.42	
7	08/21/10	5125.70	35935.15
1	08/22/10	4823.14	
2	08/23/10	5277.25	
3	08/24/10	5275.16	
4	08/25/10	5210.82	
5	08/26/10	4639.24	
6	08/27/10	3080.79	
7	08/28/10	5149.83	33456.24
1	08/29/10	4321.45	
2	08/30/10	4954.12	
3	08/31/10	1207.31	
4	09/01/10	4750.99	
5	09/02/10	4495.03	
6	09/03/10	4767.94	
7	09/04/10	4203.73	28700.56
1	09/05/10	3177.39	
2	09/06/10	661.02	
3	09/07/10	1572.75	
4	09/08/10	3861.56	
5	09/09/10	4274.32	
6	09/10/10	2118.32	
7	09/11/10	3514.68	19180.03
1	09/12/10	933.30	
2	09/13/10	1874.56	
3	09/14/10	4221.82	
4	09/15/10	1575.59	
5	09/16/10	1019.40	
6	09/17/10	2416.16	
7	09/18/10	1344.85	13385.68
1	09/19/10	2949.26	
2	09/20/10	3711.77	
3	09/21/10	3779.16	
4	09/22/10	3725.21	
5	09/23/10	1271.12	

6	09/24/10	686.30	
7	09/25/10	3564.05	19686.85
1	09/26/10	2139.73	
2	09/27/10	1140.84	
3	09/28/10	2304.32	
4	09/29/10	3568.47	
5	09/30/10	3506.36	
6	10/01/10	3345.61	
7	10/02/10	3412.09	19417.41
1	10/03/10	1389.95	
2	10/04/10	2632.52	
3	10/05/10	3147.07	
4	10/06/10	3130.42	
5	10/07/10	1377.70	
6	10/08/10	1138.12	
7	10/09/10	719.71	13535.49
1	10/10/10	2458.75	
2	10/11/10	2540.59	
3	10/12/10	1937.06	
4	10/13/10	2726.12	
5	10/14/10	907.05	
6	10/15/10	2771.67	
7	10/16/10	2468.90	15810.14
1	10/17/10	2296.94	
2	10/18/10	741.25	
3	10/19/10	2343.99	
4	10/20/10	2217.69	
5	10/21/10	1157.43	
6	10/22/10	1428.43	
7	10/23/10	1512.32	11698.05
1	10/24/10	1005.75	
2	10/25/10	643.39	
3	10/26/10	1142.39	
4	10/27/10	1262.06	
5	10/28/10	916.35	
6	10/29/10	1145.34	
7	10/30/10	1275.34	7390.61
1	10/31/10	1399.69	
2	11/01/10	628.64	
3	11/02/10	1307.26	
4	11/03/10	1876.46	
5	11/04/10	1182.88	
6	11/05/10	155.60	
7	11/06/10	409.65	6960.17
1	11/07/10	1404.41	
2	11/08/10	1420.66	
3	11/09/10	510.94	
4	11/10/10	1132.85	
5	11/11/10	434.02	
6	11/12/10	1370.09	
7	11/13/10	215.40	6488.36
1	11/14/10	366.72	
2	11/15/10	471.61	
3	11/16/10	1169.23	
4	11/17/10	563.85	
5	11/18/10	846.23	
6	11/19/10	238.07	
7	11/20/10	384.49	4040.20
1	11/21/10	381.88	
2	11/22/10	223.36	
3	11/23/10	1057.92	
4	11/24/10	278.29	
5	11/25/10	70.18	
6	11/26/10	385.75	
7	11/27/10	1020.20	3417.57
1	11/28/10	681.83	
2	11/29/10	352.26	
3	11/30/10	335.75	
4	12/01/10	497.74	
5	12/02/10	492.12	
6	12/03/10	619.91	
7	12/04/10	1077.88	4057.48
1	12/05/10	723.95	
2	12/06/10	553.31	
3	12/07/10	222.67	
4	12/08/10	373.03	

5	12/09/10	643.35	
6	12/10/10	937.16	
7	12/11/10	198.84	3652.30
1	12/12/10	386.77	
2	12/13/10	324.14	
3	12/14/10	244.22	
4	12/15/10	462.22	
5	12/16/10	196.10	
6	12/17/10	1033.31	
7	12/18/10	215.23	2861.97
1	12/19/10	506.14	
2	12/20/10	290.11	
3	12/21/10	442.29	
4	12/22/10	906.68	
5	12/23/10	261.37	
6	12/24/10	212.40	
7	12/25/10	331.94	2950.93
1	12/26/10	590.00	
2	12/27/10	405.14	
3	12/28/10	617.63	
4	12/29/10	953.54	
5	12/30/10	1044.94	
6	12/31/10	1024.43	
7	01/01/11	1035.64	5671.32
1	01/02/11	1024.36	
2	01/03/11	905.46	
3	01/04/11	436.18	
4	01/05/11	308.53	
5	01/06/11	263.62	
6	01/07/11	702.16	
7	01/08/11	1013.90	4654.20
1	01/09/11	1087.46	
2	01/10/11	313.56	
3	01/11/11	436.56	
4	01/12/11	620.21	
5	01/13/11	413.37	
6	01/14/11	761.81	
7	01/15/11	228.11	3861.08
1	01/16/11	556.50	
2	01/17/11	1283.33	
3	01/18/11	639.38	
4	01/19/11	1112.33	
5	01/20/11	200.34	
6	01/21/11	822.07	
7	01/22/11	762.52	5376.47
1	01/23/11	382.62	
2	01/24/11	364.53	
3	01/25/11	519.16	
4	01/26/11	624.81	
5	01/27/11	846.42	
6	01/28/11	441.74	
7	01/29/11	465.26	3644.54
1	01/30/11	1533.68	
2	01/31/11	1434.64	
3	02/01/11	1271.00	
4	02/02/11	1407.81	
5	02/03/11	631.48	
6	02/04/11	988.37	
7	02/05/11	921.43	8188.41
1	02/06/11	407.96	
2	02/07/11	868.53	
3	02/08/11	1277.84	
4	02/09/11	1797.46	
5	02/10/11	1940.43	
6	02/11/11	757.71	
7	02/12/11	286.67	7336.59
1	02/13/11	1575.88	
2	02/14/11	561.67	
3	02/15/11	1321.50	
4	02/16/11	1454.68	
5	02/17/11	1444.53	
6	02/18/11	1395.18	
7	02/19/11	2390.68	10144.12
1	02/20/11	2398.34	
2	02/21/11	1143.88	
3	02/22/11	1447.90	

4	02/23/11	247.07	
5	02/24/11	1194.14	
6	02/25/11	2587.25	
7	02/26/11	742.53	9761.11
1	02/27/11	554.50	
2	02/28/11	2579.87	
3	03/01/11	858.89	
4	03/02/11	1837.81	
5	03/03/11	2312.01	
6	03/04/11	919.46	
7	03/05/11	2315.79	11378.34
1	03/06/11	1659.83	
2	03/07/11	2441.37	
3	03/08/11	1283.59	
4	03/09/11	1954.82	
5	03/10/11	1687.69	
6	03/11/11	1669.44	
7	03/12/11	1249.39	11946.14
1	03/13/11	1089.26	
2	03/14/11	1720.55	
3	03/15/11	1710.84	
4	03/16/11	2822.20	
5	03/17/11	2232.82	
6	03/18/11	967.76	
7	03/19/11	2910.95	13454.38
1	03/20/11	2739.30	
2	03/21/11	1746.00	
3	03/22/11	2910.30	
4	03/23/11	4053.85	
5	03/24/11	2971.06	
6	03/25/11	1530.14	
7	03/26/11	2392.26	18342.90
1	03/27/11	1560.24	
2	03/28/11	2752.24	
3	03/29/11	1453.94	
4	03/30/11	699.63	
5	03/31/11	3668.30	
6	04/01/11	943.49	
7	04/02/11	2169.06	13246.89
1	04/03/11	1816.38	
2	04/04/11	855.79	
3	04/05/11	1902.75	
4	04/06/11	4075.76	
5	04/07/11	4782.87	
6	04/08/11	4876.99	
7	04/09/11	2680.70	20991.23
1	04/10/11	2445.60	
2	04/11/11	4513.68	
3	04/12/11	2861.29	
4	04/13/11	2207.71	
5	04/14/11	1937.40	
6	04/15/11	2483.31	
7	04/16/11	5498.14	21947.13
1	04/17/11	3245.44	
2	04/18/11	3676.25	
3	04/19/11	5260.23	
4	04/20/11	3804.09	
5	04/21/11	4773.39	
6	04/22/11	4756.15	
7	04/23/11	5946.32	31461.87
1	04/24/11	2167.73	
2	04/25/11	1947.75	
3	04/26/11	5295.27	
4	04/27/11	1977.12	
5	04/28/11	4260.91	
6	04/29/11	4005.56	
7	04/30/11	5592.22	25246.54
1	05/01/11	5754.01	
2	05/02/11	2350.32	
3	05/03/11	4072.64	
4	05/04/11	5478.34	
5	05/05/11	3692.11	
6	05/06/11	2066.93	
7	05/07/11	3619.96	27034.30
1	05/08/11	2869.84	
2	05/09/11	3291.44	
3	05/10/11	4743.07	
4	05/11/11	1493.47	
5	05/12/11	5321.61	
6	05/13/11	4979.41	
7	05/14/11	3154.23	25853.07
1	05/15/11	1348.77	
2	05/16/11	3918.16	
3	05/17/11	6733.17	
4	05/18/11	6629.35	
5	05/19/11	6927.70	
6	05/20/11	6900.14	
7	05/21/11	2405.39	34862.68
1	05/22/11	3838.17	
2	05/23/11	6398.25	
3	05/24/11	7161.20	
4	05/25/11	1744.15	
5	05/26/11	4572.75	
6	05/27/11	6329.86	
7	05/28/11	4268.11	34312.49
1	05/29/11	6906.59	
2	05/30/11	4442.83	
3	05/31/11	3975.38	
4	06/01/11	5655.81	
5	06/02/11	2554.56	
6	06/03/11	6246.93	
7	06/04/11	7852.82	37634.90
1	06/05/11	6669.64	
2	06/06/11	7429.54	
3	06/07/11	4385.94	
4	06/08/11	6815.10	
5	06/09/11	5673.69	
6	06/10/11	5932.39	
7	06/11/11	4565.26	41471.55
1	06/12/11	5899.32	
2	06/13/11	5954.68	
3	06/14/11	6374.34	
4	06/15/11	4889.63	
5	06/16/11	7506.48	
6	06/17/11	7006.07	
7	06/18/11	2593.39	40223.90
	06/19/11	5158.66	
	06/20/11	6616.85	
	06/21/11	7288.61	
	Total Insolation	1058111.64	

Based on data from Eagle View Elementary, Cal Revelle Nature Sanctuary and East Highlands Firehall

Weighted average where Eagle View elementary is weighted at 66.8% and East Highlands and Cal Revelle are weighted at 16.7% each.

This is due to some shading issues that are prevalent at both sites on the east and west of the weather staions.

Source:

Table 2 – Weekly Insolation

Week	Weekly Insolation Insolation (W/m2)
1	39681.59
2	29337.91
3	44411.00

4	47661.25	31	5376.47	
5	44883.88	32	3644.54	
6	44666.98	33	8188.41	
7	31912.36	34	7336.59	
8	35821.28	35	10144.12	
9	35935.15	36	9761.11	
10	33456.24	37	11378.34	
11	28700.56	38	11946.14	
12	19180.03	39	13454.38	
13	13385.68	40	18342.90	
14	19686.85	41	13246.89	
15	19417.41	42	20991.23	
16	13535.49	43	21947.13	
17	15810.14	44	31461.87	
18	11698.05	45	25246.54	
19	7390.61	46	27034.30	
20	6960.17	47	25853.07	
21	6488.36	48	34862.68	
22	4040.20	49	34312.49	
23	3417.57	50	37634.90	
24	4057.48	51	41471.55	
25	3652.30	52	40223.90	
26	2861.97			
27	2950.93	Total	1039047.51	W/m2
28	5671.32		1039.04751	kWhr/m2
29	4654.20			
30	3861.08			

Table 3 – Insolation Summary

	Actual Monthly Insolation (W/m2)	Actual Monthly Insolation (kWh/m2)	Average Insolation for Lat/Log from NASA (kWhr/m2/day)	AverageMonthly Insolation for Lat/Log from NASA (kWhr/m2)
Jan	21540.23	21.54	1.04	32.24
Feb	35596.28	35.60	1.91	53.48
Mar	62121.73	62.12	2.93	90.83
Apr	102759.30	102.76	4.2	126.00
May	137387.32	137.39	5.17	160.27
Jun	172680.59	172.68	5.67	170.10
Jul	193743.09	193.74	6.08	188.48
Aug	147607.89	147.61	5.4	167.40
Sep	83129.95	83.13	4.07	122.10
Oct	56591.68	56.59	2.25	69.75
Nov	20876.44	20.88	1.18	35.40
Dec	16788.53	16.79	0.86	26.66
		1050.82		1242.71

Source: NASA Atmospheric Science Data Centre ; Surface meteorlogical and Solar Energy Tables; http://eosweb.larc.nasa.gov

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m2/day)

Lat 48.5 Lon -123.467	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average 22-year Average	1.04	1.91	2.93	4.2	5.17	5.67	6.08	5.4	4.07	2.25	1.18	0.86	3.4

Table 4 – Energy Summary Data

Date	Daily Solar Thermal kWhrs	Wood kWhrs	Solar PV kWhrs	Total Energy Generated	Cumulative Energy Generated	Daily Insolation W/m 2	Daily Hot Water usage	Energy Attributed to DHW (kWhrs)	Solar thermal energy actually used	Unutilized Solar Thermal Energy (kWhr)
June 23, 2010	34.74	0	10.88	45.61	45.61	6541.07	9.1	2.76	2.76	31.98
June 24, 2010	38.60	0	10.33	48.92	94.53	5955.00	9.1	2.76	2.76	35.84
June 25, 2010	40.62	0	12.50	53.12	147.65	5683.94	9.1	2.76	2.76	37.86
June 26, 2010	36.88	0	11.65	48.53	196.18	6732.44	9.1	2.76	2.76	34.12
June 27, 2010	4.45	0	3.98	8.42	204.60	6632.95	9.1	2.76	2.76	1.69
June 28, 2010	24.36	0	7.10	31.46	236.06	2546.97	9.1	2.76	2.76	21.60
June 29, 2010	18.46	0	6.85	25.31	261.37	3910.32	9.1	2.77	2.77	15.69
June 30, 2010	38.32	0	10.35	48.67	310.04	5178.84	22.6	6.85	6.85	31.47
July 1, 2010	7.10	0	4.20	11.30	321.33	5581.79	22.6	6.85	6.85	0.25
July 2, 2010	31.03	0	8.68	39.71	361.04	2669.24	22.6	6.85	6.85	24.18
July 3, 2010	37.81	0	9.50	47.31	408.35	4296.75	22.6	6.85	6.85	30.96
July 4, 2010	32.17	0	9.50	41.67	450.01	5154.00	22.6	6.85	6.85	25.32
July 5, 2010	29.16	0	8.70	37.86	487.88	4737.56	22.6	6.85	6.85	22.31
July 6, 2010	56.39	0	13.40	69.79	557.66	4422.63	22.6	6.85	6.85	49.54
July 7, 2010	57.32	0	13.10	70.42	628.08	7263.84	30.7	9.30	9.30	48.01
July 8, 2010	17.95	0	12.80	30.75	658.83	7332.26	30.7	9.30	9.30	8.65
July 9, 2010	23.95	0	10.43	34.37	693.20	7192.80	30.7	9.30	9.30	14.64
July 10, 2010	55.75	0	13.10	68.85	762.05	6437.72	30.7	9.30	9.30	46.44
July 11, 2010	55.68	0	13.23	68.90	830.95	7024.18	30.7	9.30	9.30	46.37
July 12, 2010	51.50	0	14.50	66.00	896.95	7072.10	30.7	9.30	9.30	42.19
July 13, 2010	53.35	0	13.38	66.72	963.67	6098.60	30.7	9.30	9.30	44.04
July 14, 2010	55.71	0	13.55	69.26	1032.93	6605.04	23.9	7.24	7.24	48.47
July 15, 2010	56.77	0	13.40	70.17	1103.09	7016.18	23.9	7.24	7.24	49.52
July 16, 2010	56.08	0	13.85	69.93	1173.02	7009.94	23.9	7.24	7.24	48.84
July 17, 2010	56.22	0	13.58	69.80	1242.82	6947.16	23.9	7.24	7.24	48.98
July 18, 2010	56.91	0	13.78	70.68	1313.50	6912.24	23.9	7.24	7.24	49.66
July 19, 2010	56.34	0	13.35	69.69	1383.19	6884.76	23.9	7.24	7.24	49.09
July 20, 2010	58.39	0	12.85	71.24	1454.43	6287.53	23.9	7.24	7.24	51.15
July 21, 2010	55.96	0	12.78	68.74	1523.16	6025.81	20.7	6.27	6.27	49.69
July 22, 2010	50.19	0	11.68	61.87	1585.03	6554.02	20.7	6.27	6.27	43.92
July 23, 2010	56.88	0	13.38	70.26	1655.29	5723.10	20.7	6.27	6.27	50.61
July 24, 2010	57.78	0	13.23	71.01	1726.29	6692.80	20.7	6.27	6.27	51.51
July 25, 2010	58.94	0	13.23	72.17	1798.46	6715.86	20.7	6.27	6.27	52.67
July 26, 2010	57.68	0	12.85	70.53	1868.99	6714.87	20.7	6.27	6.27	51.41
July 27, 2010	56.66	0	13.03	69.69	1938.68	6540.25	20.7	6.29	6.29	50.38
July 28, 2010	58.39	0	13.25	71.64	2010.32	6523.75	12.7	3.85	3.85	54.54
July 29, 2010	58.40	0	13.73	72.12	2082.44	6545.14	12.7	3.85	3.85	54.55
July 30, 2010	56.82	0	13.20	70.02	2152.46	6257.86	12.7	3.85	3.85	52.97
July 31, 2010	37.73	0	10.75	48.48	2200.94	6458.39	12.7	3.85	3.85	33.88
August 1, 2010	45.28	0	10.43	55.70	2256.64	5626.72	12.7	3.85	3.85	41.43
August 2, 2010	47.19	0	10.30	57.49	2314.13	4763.92	12.7	3.85	3.85	43.34
August 3, 2010	41.80	0	9.80	51.60	2365.73	4910.13	12.7	3.84	3.84	37.96
August 4, 2010	52.55	0	11.28	63.83	2429.56	5000.02	25.7	7.79	7.79	44.76
August 5, 2010	44.40	0	9.70	54.10	2483.66	5567.35	25.7	7.79	7.79	36.61
August 6, 2010	54.93	0	12.08	67.01	2550.67	4950.88	25.7	7.79	7.79	47.14
August 7, 2010	0.00	0	1.65	1.65	2552.32	5685.98	25.7	7.79	7.79	-7.79
August 8, 2010	54.58	0	12.45	67.03	2619.35	1034.09	25.7	7.79	7.79	46.79
August 9, 2010	14.34	0	4.83	19.17	2638.51	5299.30	25.7	7.79	7.79	6.55
August 10, 2010	36.57	0	9.33	45.90	2684.41	2362.00	25.7	7.78	7.78	28.79
August 11, 2010	58.30	0	12.83	71.12	2755.53	4302.20	16.6	5.03	5.03	53.27
August 12, 2010	45.13	0	12.65	57.78	2813.31	5886.99	16.6	5.03	5.03	40.10
August 13, 2010	58.73	0	12.48	71.20	2884.51	5843.38	16.6	5.03	5.03	53.69
August 14, 2010	61.86	0	12.20	74.06	2958.57	6040.45	16.6	5.03	5.03	56.82
August 15, 2010	61.94	0	12.05	73.99	3032.56	6086.96	16.6	5.03	5.03	56.91
August 16, 2010	60.00	0	12.23	72.23	3104.78	5946.09	16.6	5.03	5.03	54.97
August 17, 2010	58.56	0	13.03	71.58	3176.36	5573.68	16.6	5.02	5.02	53.54
August 18, 2010	59.12	0	9.13	68.24	3244.61	5562.50	27.9	8.46	8.46	50.66
August 19, 2010	42.10	0	10.38	52.48	3297.08	5518.98	27.9	8.46	8.46	33.65
August 20, 2010	48.07	0	12.25	60.32	3357.40	3653.78	27.9	8.46	8.46	39.61
August 21, 2010	55.50	0	12.80	68.30	3425.70	4554.42	27.9	8.46	8.46	47.04
August 22, 2010	55.92	0	12.43	68.35	3494.04	5125.70	27.9	8.46	8.46	47.46
August 23, 2010	46.49	0	12.43	58.91	3552.95	4823.14	27.9	8.46	8.46	38.03
August 24, 2010	62.09	0	12.45	74.54	3627.49	5277.25	27.9	8.46	8.46	53.63
August 25, 2010	62.07	0	12.43	74.49	3701.98	5275.16	29.0	8.79	8.79	53.28
August 26, 2010	54.86	0	12.13	66.99	3768.97	5210.82	29.0	8.79	8.79	46.07
August 27, 2010	19.45	0	6.13	25.58	3794.55	4639.24	29.0	8.79	8.79	10.66
August 28, 2010	63.24	0	12.85	76.09	3870.64	3080.79	29.0	8.79	8.79	54.45
August 29, 2010	42.23	0	9.90	52.13	3922.77	5149.83	29.0	8.79	8.79	33.44
August 30, 2010	60.99	0	12.63	73.62	3996.39	4321.45	29.0	8.79	8.79	52.20
August 31, 2010	2.50	0	1.83	4.33	4000.72	4954.12	29.0	8.80	8.80	-6.30
September 1, 2010	49.27	0	10.08	59.34	4060.06	1207.31	34.2	10.37	10.37	38.90
September 2, 2010	53.67	0	11.10	64.77	4124.83	4750.99	34.2	10.37	10.37	43.30
September 3, 2010	63.53	0	12.33	75.85	4200.68	4495.03	34.2	10.37	10.37	53.16
September 4, 2010	28.03	0	7.40	35.43	4236.11	4767.94	34.2	10.37	10.37	17.67
September 5, 2010	28.90	0	6.80	35.70	4271.81	4203.73	34.2	10.37	10.37	18.54
September 6, 2010	0.00	0	0.85	0.85	4272.66	3177.39	34.2	10.37	10.37	-10.37
September 7, 2010	9.45	0	3.35	12.80	4285.46	661.02	34.2	10.38	10.38	-0.93
September 8, 2010	37.08	0	7.95	45.03	4330.50	1572.75	24.7	7.49	37.08	0.00
September 9, 2010	56.80	0	11.45	68.25	4398.74	3861.56	24.7	7.49	56.80	0.00
September 10, 2010	15.70	0	4.63	20.33	4419.07	4274.32	24.7	7.49	15.70	0.00
September 11, 2010	36.92	0	7.85	44.77	4463.84	2118.32	24.7	7.49	36.92	0.00
September 12, 2010	0.58	97.698	1.40	99.68	4563.52	3514.68	24.7	7.49	0.58	0.00
September 13, 2010	14.18	30.574	4.03	48.78	4612.30	933.30	24.7	7.49	14.18	0.00
September 14, 2010	63.38	0	11.45	74.83	4687.13	1874.56	24.7	7.48	63.38	0.00
September 15, 2010	4.97	0	2.78	7.74	4694.87	4221.82	37.9	11.49	4.97	0.00
September 16, 2010	2.47	0	1.83	4.30	4699.17	1575.59	37.9	11.49	2.47	0.00
September 17, 2010	32.73	83.93	6.55	123.21	4822.37	1019.40	37.9	11.49	32.73	0.00
September 18, 2010	8.49	0	3.05	11.54	4833.92	2416.16	37.9	11.49	8.49	0.00
September 19, 2010	37.11	0	7.60	44.71	4878.63	1344.85	37.9	11.49	37.11	0.00
September 20, 2010	45.93	0	11.80	57.73	4936.36	2949.26	37.9	11.49	45.93	0.00
September 21, 2010	51.01	0	10.25	61.26	4997.62	3711.77	37.9	11.48	51.01	0.00
September 22, 2010	51.55	0	9.85	61.40	5059.02	3779.16	26.7	8.09	51.55	0.00
September 23, 2010	4.82	0	2.40	7.22	5066.24	3725.21	26.7	8.09	4.82	0.00
September 24, 2010	0.00	91.277	0.85	92.13	5158.37	1271.12	26.7	8.09	0.00	0.00
September 25, 2010	58.16	0	10.03	68.18	5226.55	686.30	26.7	8.09	58.16	0.00
September 26, 2010	12.25	0	3.60	15.85	5242.40	3564.05	26.7	8.09	12.25	0.00
September 27, 2010	2.52	0	2.00	4.52	5246.92	2139.73	26.7	8.09	2.52	0.00
September 28, 2010	41.42	0	7.55	48.97	5295.89	1140.84	26.7	8.11	41.42	0.00

September 29, 2010	48.50	0	10.83	59.33	5355.21	2304.32	20.7	6.27	48.50	0.00
September 30, 2010	65.23	0	10.65	75.88	5431.09	3568.47	20.7	6.27	65.23	0.00
October 1, 2010	60.72	0	10.03	70.74	5501.84	3506.36	20.7	6.27	60.72	0.00
October 2, 2010	60.31	0	9.85	70.16	5572.00	3345.61	20.7	6.27	60.31	0.00
October 3, 2010	13.88	0	3.38	17.25	5589.25	3412.09	20.7	6.27	13.88	0.00
October 4, 2010	30.57	0	6.40	36.97	5626.22	1389.95	20.7	6.27	30.57	0.00
October 5, 2010	60.00	0	9.80	69.80	5696.01	2632.52	20.7	6.28	60.00	0.00
October 6, 2010	62.63	0	10.03	72.66	5768.67	3147.07	8.6	2.61	62.63	0.00
October 7, 2010	24.62	57.396	2.98	84.99	5853.66	3130.42	8.6	2.61	24.62	0.00
October 8, 2010	40.89	16.877	2.23	59.99	5913.65	1377.70	8.6	2.61	40.89	0.00
October 9, 2010	1.13	133.033	1.05	135.21	6048.87	1138.12	8.6	2.61	1.13	0.00
October 10, 2010	59.50	2.001	9.00	70.50	6119.36	719.71	8.6	2.61	59.50	0.00
October 11, 2010	41.05	0	7.23	48.27	6167.63	2458.75	8.6	2.61	41.05	0.00
October 12, 2010	25.00	108.54	5.58	139.12	6306.75	2540.59	8.6	2.60	25.00	0.00
October 13, 2010	0.00	0	13.73	13.73	6320.48	1937.06	14.3	4.33	0.00	0.00
October 14, 2010	37.76	161.772	1.88	201.41	6521.89	2726.12	14.3	4.33	37.76	0.00
October 15, 2010	37.76	0	11.80	49.56	6571.45	907.05	14.3	4.33	37.76	0.00
October 16, 2010	37.76	0	13.20	50.96	6622.41	2771.67	14.3	4.33	37.76	0.00
October 17, 2010	37.76	60.379	12.75	110.89	6733.30	2468.90	14.3	4.33	37.76	0.00
October 18, 2010	37.76	173.324	1.23	212.31	6945.61	2296.94	14.3	4.33	37.76	0.00
October 19, 2010	37.76	92.767	12.88	143.40	7089.02	741.25	14.3	4.32	37.76	0.00
October 20, 2010	37.76	0	12.50	50.26	7139.28	2343.99	12.5	3.79	37.76	0.00
October 21, 2010	37.76	69.751	3.63	111.14	7250.42	2217.69	12.5	3.79	37.76	0.00
October 22, 2010	37.76	76.976	3.65	118.39	7368.80	1157.43	12.5	3.79	37.76	0.00
October 23, 2010	37.76	0	5.30	43.06	7411.87	1428.43	12.5	3.79	37.76	0.00
October 24, 2010	37.76	180.608	3.45	221.82	7633.69	1512.32	12.5	3.79	37.76	0.00
October 25, 2010	0.44	109.141	1.05	110.63	7744.31	1005.75	12.5	3.79	0.44	0.00
October 26, 2010	4.86	40.274	1.80	46.93	7791.24	643.39	12.5	3.80	4.86	0.00
October 27, 2010	30.77	167.97	5.48	204.21	7995.45	1142.39	34.5	10.46	30.77	0.00
October 28, 2010	7.01	108.321	2.08	117.41	8112.86	1262.06	34.5	10.46	7.01	0.00
October 29, 2010	37.72	98.649	3.03	139.39	8252.25	916.35	34.5	10.46	37.72	0.00
October 30, 2010	37.78	148.693	3.10	189.58	8441.83	1145.34	34.5	10.46	37.78	0.00
October 31, 2010	48.33	94.811	4.68	147.82	8589.64	1275.34	34.5	10.46	48.33	0.00
November 1, 2010	0.35	119.592	0.90	120.84	8710.48	1399.69	34.5	10.46	0.35	0.00
November 2, 2010	64.43	167.936	7.23	239.60	8950.08	628.64	34.5	10.47	64.43	0.00
November 3, 2010	0.00	0	12.10	12.10	8962.18	1307.26	34.6	10.49	0.00	0.00
November 4, 2010	0.00	61.058	4.20	65.26	9027.44	1876.46	34.6	10.49	0.00	0.00
November 5, 2010	0.00	0	0.03	0.03	9027.46	1182.88	34.6	10.49	0.00	0.00
November 6, 2010	0.00	167.204	0.68	167.88	9195.34	155.60	34.6	10.49	0.00	0.00
November 7, 2010	40.68	55.218	8.50	104.40	9299.74	409.65	34.6	10.49	40.68	0.00
November 8, 2010	0.00	98.304	6.73	105.03	9404.77	1404.41	34.6	10.49	0.00	0.00
November 9, 2010	0.00	138.261	0.43	138.69	9543.45	1420.66	34.6	10.50	0.00	0.00
November 10, 2010	3.24	131.206	4.05	138.50	9681.95	510.94	22.3	6.76	3.24	0.00
November 11, 2010	0.00	60.544	0.60	61.14	9743.10	1132.85	22.3	6.76	0.00	0.00
November 12, 2010	13.62	184.429	5.45	203.49	9946.59	434.02	22.3	6.76	13.62	0.00
November 13, 2010	0.00	56.734	0.20	56.93	10003.52	1370.09	22.3	6.76	0.00	0.00
November 14, 2010	0.00	124.688	0.63	125.31	10128.84	215.40	22.3	6.76	0.00	0.00
November 15, 2010	4.31	105.194	1.68	111.18	10240.02	366.72	22.3	6.76	4.31	0.00
November 16, 2010	10.10	98.634	4.50	113.23	10353.25	471.61	22.3	6.77	10.10	0.00
November 17, 2010	15.05	50.458	4.43	69.94	10423.19	1169.23	10.8	3.27	15.05	0.00
November 18, 2010	10.67	193.324	3.63	207.62	10630.81	563.85	10.8	3.27	10.67	0.00
November 19, 2010	0.00	110.128	0.10	110.23	10741.04	846.23	10.8	3.27	0.00	0.00
November 20, 2010	1.79	197.848	1.58	201.21	10942.25	238.07	10.8	3.27	1.79	0.00
November 21, 2010	0.95	181.201	1.40	183.55	11125.80	384.49	10.8	3.27	0.95	0.00
November 22, 2010	0.00	196.273	0.03	196.30	11322.10	381.88	10.8	3.27	0.00	0.00
November 23, 2010	25.35	264.293	9.70	299.35	11621.45	223.36	10.8	3.27	25.35	0.00
November 24, 2010	0.00	148.965	0.05	149.02	11770.46	1057.92	19.8	6.00	0.00	0.00
November 25, 2010	0.00	293.027	0.00	293.03	12063.49	278.29	19.8	6.00	0.00	0.00
November 26, 2010	2.03	202.312	1.10	205.44	12268.93	70.18	19.8	6.00	2.03	0.00
November 27, 2010	30.79	113.908	8.45	153.15	12422.08	385.75	19.8	6.00	30.79	0.00
November 28, 2010	13.95	103.622	4.30	121.87	12543.94	1020.20	19.8	6.00	13.95	0.00
November 29, 2010	0.00	85.362	0.30	85.66	12629.60	681.83	19.8	6.00	0.00	0.00
November 30, 2010	0.12	154.241	0.63	154.98	12784.59	352.26	19.8	6.00	0.12	0.00
December 1, 2010	0.17	184.713	0.85	185.74	12970.32	335.75	13.1	3.97	0.17	0.00
December 2, 2010	0.00	154.941	0.90	155.84	13126.16	497.74	13.1	3.97	0.00	0.00
December 3, 2010	4.23	129.965	2.15	136.34	13262.50	492.12	13.1	3.97	4.23	0.00
December 4, 2010	28.50	49.142	8.13	85.76	13348.27	619.91	13.1	3.97	28.50	0.00
December 5, 2010	10.33	242.326	4.55	257.21	13605.47	1077.88	13.1	3.97	10.33	0.00
December 6, 2010	0.93	125.799	1.30	128.03	13733.50	723.95	13.1	3.97	0.93	0.00
December 7, 2010	0.00	180.728	0.20	180.93	13914.43	553.31	13.1	3.98	0.00	0.00
December 8, 2010	0.15	134.976	0.60	135.73	14050.16	222.67	18.1	5.49	0.15	0.00
December 9, 2010	12.80	98.07	4.00	114.87	14165.03	373.03	18.1	5.49	12.80	0.00
December 10, 2010	11.81	66.707	4.33	82.84	14247.87	643.35	18.1	5.49	11.81	0.00
December 11, 2010	0.00	159.882	0.08	159.96	14407.83	937.16	18.1	5.49	0.00	0.00
December 12, 2010	0.50	86.793	0.85	88.14	14495.97	198.84	18.1	5.49	0.50	0.00
December 13, 2010	0.00	118.78	0.45	119.23	14615.20	386.77	18.1	5.49	0.00	0.00
December 14, 2010	2.31	113.946	1.53	117.78	14732.98	324.14	18.1	5.48	2.31	0.00
December 15, 2010	0.21	273.173	0.68	274.06	15007.04	244.22	12.4	3.76	0.21	0.00
December 16, 2010	0.00	168.945	0.08	169.02	15176.06	462.22	12.4	3.76	0.00	0.00
December 17, 2010	31.05	112.067	7.73	150.84	15326.90	196.10	12.4	3.76	31.05	0.00
December 18, 2010	0.00	133.016	0.08	133.09	15459.99	1033.31	12.4	3.76	0.00	0.00
December 19, 2010	10.86	106.977	3.83	121.66	15581.64	215.23	12.4	3.76	10.86	0.00
December 20, 2010	0.00	135.811	0.08	135.89	15717.53	506.14	12.4	3.76	0.00	0.00
December 21, 2010	0.80	112.118	0.88	113.79	15831.32	290.11	12.4	3.75	0.80	0.00
December 22, 2010	25.50	123.942	7.08	156.51	15987.83	442.29	17.5	5.30	25.50	0.00
December 23, 2010	0.00	116.99	0.25	117.24	16105.07	906.68	17.5	5.30	0.00	0.00
December 24, 2010	0.00	143.549	0.10	143.65	16248.72	261.37	17.5	5.30	0.00	0.00
December 25, 2010	0.00	82.473	0.40	82.87	16331.59	212.40	17.5	5.30	0.00	0.00
December 26, 2010	1.37	96.477	1.28	99.12	16430.72	331.94	17.5	5.30	1.37	0.00
December 27, 2010	0.05	124.985	0.53	125.56	16556.28	590.00	17.5	5.30	0.05	0.00
December 28, 2010	4.22	133.006	2.05	139.28	16695.55	405.14	17.5	5.30	4.22	0.00
December 29, 2010	24.82	1.442	7.63	33.89	16729.44	617.63	13.1	3.97	24.82	0.00
December 30, 2010	36.85	100.614	10.15	147.61	16877.05	953.54	13.1	3.97	36.85	0.00
December 31, 2010	38.17	196.029	10.05	244.25	17121.31	1044.94	13.1	3.97	38.17	0.00
January 1, 2011	37.64	101.81	8.85	148.30	17269.61	1024.43	13.1	3.97	37.64	0.00
January 2, 2011	28.53	125.48	9.80	163.81	17433.42	1035.64	13.1	3.97	28.53	0.00
January 3, 2011	40.39	77.113	9.15	126.65	17560.07	1024.36	13.1	3.97	40.39	0.00
January 4, 2011	0.65	285.808	0.83	287.28	17847.35	905.46	13.1	3.97	0.65	0.00
January 5, 2011	0.00	231.345	0.30	231.65	18079.00	436.18	18.6	5.64	0.00	0.00
January 6, 2011	0.00	109.718	0.28	109.99	18188.99	308.53	18.6	5.64	0.00	0.00
January 7, 2011	18.54	149.665	5.28	173.48	18362.47	263.62	18.6	5.64	18.54	0.00
January 8, 2011	37.39	91.373	6.58	135.33	18497.81	702.16	18.6	5.64	37.39	0.00
January 9, 2011	36.06	148.431	8.28	192.77	18690.57	1013.90	18.6	5.64	36.06	0.00
January 10, 2011	0.00	85.646	0.30	85.95	18776.52	1087.46	18.6	5.64	0.00	0.00
January 11, 2011	0.00	172.809	0.68	173.48	18950.00	313.56	18.6	5.64	0.00	0.00
January 12, 2011	1.72	88.787	1.10	91.60	19041.61	436.56	23.8	7.21	1.72	0.00

January 13, 2011	0.00	169.306	0.45	169.76	19211.36	620.21	23.8	7.21	0.00	0.00
January 14, 2011	20.00	63.694	3.23	86.92	19298.28	413.37	23.8	7.21	20.00	0.00
January 15, 2011	0.00	77.568	0.08	77.64	19375.93	761.81	23.8	7.21	0.00	0.00
January 16, 2011	17.84	65.779	2.75	86.37	19462.30	228.11	23.8	7.21	17.84	0.00
January 17, 2011	13.58	0	5.95	19.53	19481.83	556.50	23.8	7.21	13.58	0.00
January 18, 2011	1.98	120.154	1.48	123.61	19605.44	1283.33	23.8	7.20	1.98	0.00
January 19, 2011	15.17	138.83	6.00	160.00	19765.43	639.38	22.3	6.76	15.17	0.00
January 20, 2011	0.00	88.807	0.05	88.86	19854.29	1112.33	22.3	6.76	0.00	0.00
January 21, 2011	8.49	128.118	4.28	140.88	19995.17	200.34	22.3	6.76	8.49	0.00
January 22, 2011	1.97	31.449	1.68	35.10	20030.27	822.07	22.3	6.76	1.97	0.00
January 23, 2011	0.00	153.241	0.63	153.87	20184.14	762.52	22.3	6.76	0.00	0.00
January 24, 2011	0.25	105.795	0.68	106.72	20290.85	382.62	22.3	6.76	0.25	0.00
January 25, 2011	0.43	90.836	0.88	92.14	20382.99	364.53	22.3	6.76	0.43	0.00
January 26, 2011	1.63	85.769	1.28	88.68	20471.66	519.16	16.4	4.97	1.63	0.00
January 27, 2011	3.66	49.483	2.08	55.22	20526.88	624.81	16.4	4.97	3.66	0.00
January 28, 2011	0.06	64.631	0.48	65.17	20592.05	846.42	16.4	4.97	0.06	0.00
January 29, 2011	0.00	125.499	0.63	126.12	20718.17	441.74	16.4	4.97	0.00	0.00
January 30, 2011	20.09	112.268	7.13	139.48	20857.65	465.26	16.4	4.97	20.09	0.00
January 31, 2011	19.22	67.96	6.55	93.73	20951.38	1533.68	16.4	4.97	19.22	0.00
February 1, 2011	25.60	76.682	8.30	110.58	21061.97	1434.64	16.4	4.97	25.60	0.00
February 2, 2011	16.19	87.47	6.08	109.73	21171.70	1271.00	21.0	6.36	16.19	0.00
February 3, 2011	0.17	72.004	1.05	73.22	21244.92	1407.81	21.0	6.36	0.17	0.00
February 4, 2011	13.10	116.442	5.78	135.31	21380.23	631.48	21.0	6.36	13.10	0.00
February 5, 2011	1.12	41.462	1.48	44.06	21424.29	988.37	21.0	6.36	1.12	0.00
February 6, 2011	0.00	74.694	0.48	75.17	21499.46	921.43	21.0	6.36	0.00	0.00
February 7, 2011	2.82	54.777	2.03	59.62	21559.08	407.96	21.0	6.36	2.82	0.00
February 8, 2011	20.33	86.847	6.78	113.95	21673.04	868.53	21.0	6.35	20.33	0.00
February 9, 2011	20.66	104.361	6.75	131.77	21804.81	1277.84	15.9	4.82	20.66	0.00
February 10, 2011	31.51	53.484	9.55	94.55	21899.35	1797.46	15.9	4.82	31.51	0.00
February 11, 2011	1.21	142.757	1.45	145.42	22044.77	1940.43	15.9	4.82	1.21	0.00
February 12, 2011	0.00	127.208	0.28	127.48	22172.25	757.71	15.9	4.82	0.00	0.00
February 13, 2011	16.01	75.982	5.45	97.44	22269.69	286.67	15.9	4.82	16.01	0.00
February 14, 2011	0.90	114.004	0.88	115.78	22385.47	1575.88	15.9	4.82	0.90	0.00
February 15, 2011	3.61	70.889	2.30	76.80	22462.27	561.67	15.9	4.82	3.61	0.00
February 16, 2011	13.65	65.144	5.33	84.12	22546.39	1321.50	23.4	7.09	13.65	0.00
February 17, 2011	6.66	143.635	3.48	153.77	22700.16	1454.68	23.4	7.09	6.66	0.00
February 18, 2011	6.84	79.181	3.28	89.29	22789.45	1444.53	23.4	7.09	6.84	0.00
February 19, 2011	51.71	111.624	14.63	177.95	22967.40	1395.18	23.4	7.09	51.71	0.00
February 20, 2011	38.28	67.493	11.43	117.20	23084.60	2390.68	23.4	7.09	38.28	0.00
February 21, 2011	5.98	79.275	3.40	88.65	23173.25	2398.34	23.4	7.09	5.98	0.00
February 22, 2011	9.57	118.029	3.50	131.10	23304.35	1143.88	23.4	7.11	9.57	0.00
February 23, 2011	0.03	149.716	0.00	149.75	23454.10	1447.90	14.2	4.30	0.03	0.00
February 24, 2011	11.64	191.584	3.03	206.25	23660.35	247.07	14.2	4.30	11.64	0.00
February 25, 2011	40.92	89.034	16.00	145.95	23806.30	1194.14	14.2	4.30	40.92	0.00
February 26, 2011	0.16	141.914	1.23	143.30	23949.60	2587.25	14.2	4.30	0.16	0.00
February 27, 2011	0.00	115.94	0.85	116.79	24066.39	742.53	14.2	4.30	0.00	0.00
February 28, 2011	42.23	59.213	11.45	112.90	24179.28	554.50	14.2	4.30	42.23	0.00
March 1, 2011	1.61	136.853	1.50	139.97	24319.25	2579.87	14.2	4.30	1.61	0.00
March 2, 2011	21.80	138.248	6.30	166.34	24485.59	858.89	22.0	6.67	21.80	0.00
March 3, 2011	29.47	0	6.88	36.34	24521.93	1837.81	22.0	6.67	29.47	0.00
March 4, 2011	2.56	153.867	2.03	158.45	24680.38	2312.01	22.0	6.67	2.56	0.00
March 5, 2011	30.88	58.894	8.88	98.65	24779.03	919.46	22.0	6.67	30.88	0.00
March 6, 2011	6.46	1.39	3.63	11.48	24790.51	2315.79	22.0	6.67	6.46	0.00
March 7, 2011	19.32	257.385	6.65	283.36	25073.87	1659.83	22.0	6.67	19.32	0.00
March 8, 2011	8.81	259.267	4.25	272.33	25346.19	2441.37	22.0	6.66	8.81	0.00
March 9, 2011	19.70	182.629	7.80	210.13	25556.32	1283.59	13.9	4.21	19.70	0.00
March 10, 2011	6.60	104.48	4.48	115.56	25671.88	1954.82	13.9	4.21	6.60	0.00
March 11, 2011	6.05	73.068	3.83	82.94	25754.81	1687.69	13.9	4.21	6.05	0.00
March 12, 2011	8.49	126.12	4.08	138.69	25893.50	1669.44	13.9	4.21	8.49	0.00
March 13, 2011	1.94	104.549	2.10	108.59	26002.09	1249.39	13.9	4.21	1.94	0.00
March 14, 2011	9.73	93.936	5.08	108.74	26110.83	1089.26	13.9	4.21	9.73	0.00
March 15, 2011	8.21	60.841	4.50	73.55	26184.38	1720.55	13.9	4.23	8.21	0.00
March 16, 2011	29.90	0	10.35	40.25	26224.62	1710.84	28.8	8.73	29.90	0.00
March 17, 2011	15.01	21.263	6.20	42.47	26267.09	2822.20	28.8	8.73	15.01	0.00
March 18, 2011	1.55	101.307	2.03	104.88	26371.97	2232.82	28.8	8.73	1.55	0.00
March 19, 2011	31.33	0	9.63	40.95	26412.92	967.76	28.8	8.73	31.33	0.00
March 20, 2011	22.59	79.54	8.45	110.58	26523.50	2910.95	28.8	8.73	22.59	0.00
March 21, 2011	8.52	83.868	4.70	97.09	26620.59	2739.30	28.8	8.73	8.52	0.00
March 22, 2011	23.26	0	8.80	32.06	26652.65	1746.00	28.8	8.74	23.26	0.00
March 23, 2011	55.01	55.874	15.40	126.28	26778.93	2910.30	20.7	6.27	55.01	0.00
March 24, 2011	28.32	0	9.23	37.55	26816.47	4053.85	20.7	6.27	28.32	0.00
March 25, 2011	13.29	154.01	5.25	172.55	26989.03	2971.06	20.7	6.27	13.29	0.00
March 26, 2011	15.02	45.782	6.78	67.58	27056.61	1530.14	20.7	6.27	15.02	0.00
March 27, 2011	2.20	67.646	2.90	72.74	27129.35	2392.26	20.7	6.27	2.20	0.00
March 28, 2011	18.59	0	7.00	25.59	27154.94	1560.24	20.7	6.27	18.59	0.00
March 29, 2011	2.20	92.429	3.05	97.68	27252.62	2752.24	20.7	6.28	2.20	0.00
March 30, 2011	1.33	94.621	1.80	97.75	27350.38	1453.94	19.6	5.94	1.33	0.00
March 31, 2011	40.24	52.5	13.00	105.74	27456.11	699.63	19.6	5.94	40.24	0.00
April 1, 2011	0.55	115.47	2.30	118.32	27574.43	3668.30	19.6	5.94	0.55	0.00
April 2, 2011	12.37	95.82	5.38	113.56	27688.00	943.49	19.6	5.94	12.37	0.00
April 3, 2011	6.14	39.314	4.45	49.91	27737.90	2169.06	19.6	5.94	6.14	0.00
April 4, 2011	0.00	131.425	1.65	133.08	27870.98	1816.38	19.6	5.94	0.00	0.00
April 5, 2011	8.93	123.351	5.88	138.15	28009.13	855.79	19.6	5.93	8.93	0.00
April 6, 2011	44.91	103.19	14.75	162.85	28171.98	1902.75	14.2	4.30	44.91	0.00
April 7, 2011	49.90	0	14.95	64.85	28236.83	4075.76	14.2	4.30	49.90	0.00
April 8, 2011	55.08	18.856	16.05	89.98	28326.81	4782.87	14.2	4.30	55.08	0.00
April 9, 2011	17.51	0	7.45	24.96	28351.77	4876.99	14.2	4.30	17.51	0.00
April 10, 2011	12.10	69.993	6.00	88.09	28439.86	2680.70	14.2	4.30	12.10	0.00
April 11, 2011	52.76	0	17.25	70.01	28509.87	2445.60	14.2	4.30	52.76	0.00
April 12, 2011	18.13	42.66	7.18	67.97	28577.83	4513.68	14.2	4.30	18.13	0.00
April 13, 2011	10.14	89.035	6.23	105.40	28683.24	2861.29	25.2	7.64	10.14	0.00
April 14, 2011	7.21	42.303	5.40	54.92	28738.15	2207.71	25.2	7.64	7.21	0.00
April 15, 2011	11.21	67.976	6.43	85.61	28823.76	1937.40	25.2	7.64	11.21	0.00
April 16, 2011	57.51	51.03	18.55	127.09	28950.86	2483.31	25.2	7.64	57.51	0.00
April 17, 2011	16.73	0	8.38	25.11	28975.96	5498.14	25.2	7.64	16.73	0.00
April 18, 2011	24.25	0	9.38	33.63	29009.59	3245.44	25.2	7.64	24.25	0.00
April 19, 2011	48.59	37.726	15.50	101.81	29111.40	3676.25	25.2	7.65	48.59	0.00
April 20, 2011	30.45	60.951	10.80	102.21	29213.60	5260.23	14.8	4.49	30.45	0.00
April 21, 2011	36.94	7.874	13.40	58.22	29271.82	3804.09	14.8	4.49	36.94	0.00
April 22, 2011	53.00	0	16.03	69.03	29340.85	4773.39	14.8	4.49	53.00	0.00
April 23, 2011	62.39	0	18.13	80.51	29421.36	4756.15	14.8	4.49	62.39	0.00
April 24, 2011	8.12	51.274	5.05	64.45	29485.80	5946.32	14.8	4.49	8.12	0.00
April 25, 2011	9.50	28.403	5.63	43.52	29529.33	2167.73	14.8	4.49	9.50	0.00
April 26, 2011	37.12	0	13.20	50.32	29579.64	1947.75	14.8	4.47	37.12	0.00
April 27, 2011	4.12	40.666	4.45	49.24	29628.88	5295.27	22.3	6.76	4.12	0.00
April 28, 2011	36.94	0	15.90	52.84	29681.72	1977.12	22.3	6.76	36.94	0.00

April 29, 2011	20.28	0	9.00	29.28	29711.00	4260.91	22.3	6.76	20.28	0.00
April 30, 2011	58.45	0	17.65	76.10	29787.10	4005.56	22.3	6.76	58.45	0.00
May 1, 2011	57.28	0	17.45	74.73	29861.83	5592.22	22.3	6.76	57.28	0.00
May 2, 2011	14.64	121.29	7.03	142.95	30004.78	5754.01	22.3	6.76	14.64	0.00
May 3, 2011	16.34	0	8.95	25.29	30030.07	2350.32	22.3	6.75	16.34	0.00
May 4, 2011	48.80	0	15.73	64.53	30094.60	4072.64	10.0	3.03	48.80	0.00
May 5, 2011	17.91	45.247	8.53	71.68	30166.28	5478.34	10.0	3.03	17.91	0.00
May 6, 2011	5.33	131.931	4.80	142.07	30308.34	3692.11	10.0	3.03	5.33	0.00
May 7, 2011	21.69	53.663	9.88	85.23	30393.57	2066.93	10.0	3.03	21.69	0.00
May 8, 2011	12.36	53.156	6.63	72.15	30465.72	3619.96	10.0	3.03	12.36	0.00
May 9, 2011	5.79	22.256	10.23	38.27	30503.99	2869.84	10.0	3.03	5.79	0.00
May 10, 2011	33.84	0	10.90	44.74	30548.73	3291.44	10.0	3.04	33.84	0.00
May 11, 2011	33.84	90.964	4.05	128.86	30677.59	4743.07	17.1	5.18	33.84	0.00
May 12, 2011	33.84	0	13.20	47.04	30724.63	1493.47	17.1	5.18	33.84	0.00
May 13, 2011	33.84	0	13.58	47.42	30772.04	5321.61	17.1	5.18	33.84	0.00
May 14, 2011	33.84	0	7.28	41.12	30813.16	4979.41	17.1	5.18	33.84	0.00
May 15, 2011	33.84	117.062	3.05	153.95	30967.12	3154.23	17.1	5.18	33.84	0.00
May 16, 2011	33.84	0	12.00	45.84	31012.96	1348.77	17.1	5.18	33.84	0.00
May 17, 2011	33.84	32.722	18.63	85.19	31098.15	3918.16	17.1	5.19	33.84	0.00
May 18, 2011	33.84	52.266	18.05	104.16	31202.31	6733.17	14.3	4.33	33.84	0.00
May 19, 2011	33.84	0	18.68	52.52	31254.82	6629.35	14.3	4.33	33.84	0.00
May 20, 2011	33.84	0	17.05	50.89	31305.71	6927.70	14.3	4.33	33.84	0.00
May 21, 2011	33.84	32.002	5.40	71.24	31376.96	6900.14	14.3	4.33	33.84	0.00
May 22, 2011	33.84	32.187	10.38	76.40	31453.36	2405.39	14.3	4.33	33.84	0.00
May 23, 2011	16.55	0	8.03	24.57	31477.94	3838.17	14.3	4.33	16.55	0.00
May 24, 2011	56.18	0	18.08	74.25	31552.19	6398.25	14.3	4.32	56.18	0.00
May 25, 2011	4.27	37.529	3.88	45.67	31597.86	7161.20	30.8	9.33	4.27	0.00
May 26, 2011	24.76	0	11.50	36.26	31634.12	1744.15	30.8	9.33	24.76	0.00
May 27, 2011	51.48	0	17.88	69.36	31703.48	4572.75	30.8	9.33	51.48	0.00
May 28, 2011	21.34	0	10.08	31.41	31734.89	6329.86	30.8	9.33	21.34	0.00
May 29, 2011	55.29	0	18.25	73.54	31808.43	4268.11	30.8	9.33	55.29	0.00
May 30, 2011	23.73	0	11.03	34.75	31843.18	6906.59	30.8	9.33	23.73	0.00
May 31, 2011	24.45	51.022	10.15	85.62	31928.80	4442.83	30.8	9.33	24.45	0.00
June 1, 2011	32.65	3.96	12.03	48.64	31977.44	3975.38	29.8	9.03	32.65	0.00
June 2, 2011	6.58	0	5.45	12.03	31989.47	5655.81	29.8	9.03	9.03	-2.45
June 3, 2011	40.30	0	16.38	56.68	32046.15	2554.56	29.8	9.03	9.03	31.27
June 4, 2011	60.51	0	18.60	79.11	32125.26	6246.93	29.8	9.03	9.03	51.48
June 5, 2011	47.68	0	14.88	62.55	32187.81	7852.82	29.8	9.03	9.03	38.64
June 6, 2011	59.54	0	18.25	77.79	32265.60	6669.64	29.8	9.03	9.03	50.50
June 7, 2011	33.36	0	13.18	46.54	32312.13	7429.54	29.8	9.04	9.04	24.32
June 8, 2011	51.30	0	16.65	67.95	32380.08	4385.94	29.0	8.79	8.79	42.51
June 9, 2011	39.81	0	13.95	53.76	32433.84	6815.10	29.0	8.79	8.79	31.02
June 10, 2011	44.29	0	15.58	59.87	32493.71	5673.69	29.0	8.79	8.79	35.50
June 11, 2011	22.99	0	9.78	32.77	32526.47	5932.39	29.0	8.79	8.79	14.20
June 12, 2011	34.45	0	12.90	47.35	32573.82	4565.26	29.0	8.79	8.79	25.66
June 13, 2011	51.78	0	17.80	69.58	32643.40	5899.32	29.0	8.79	8.79	42.99
June 14, 2011	40.16	0	15.30	55.46	32698.86	5954.68	29.0	8.78	8.78	31.38
June 15, 2011	25.30	0	11.93	37.23	32736.09	6374.34	33.5	10.15	10.15	15.15
June 16, 2011	53.95	0	18.25	72.20	32808.28	4889.63	33.5	10.15	10.15	43.79
June 17, 2011	48.33	0	16.40	64.73	32873.01	7506.48	33.5	10.15	10.15	38.17
June 18, 2011	8.00	0	5.88	13.88	32886.89	7006.07	33.5	10.15	10.15	-2.15
June 19, 2011	3.08	0	13.58	16.66	32903.55	2593.39	33.5	10.15	10.15	-7.07
June 20, 2011	0.00	0	15.55	15.55	32919.10	5158.66	33.5	10.15	10.15	-10.15
June 21, 2011	0.00	0	17.63	17.63	32936.72	6616.85	33.5	10.15	10.15	-10.15
June 22, 2011	0.00	0	18.98	18.98	32955.70	7288.61			0.00	0.00
						1042686.8				
Totals (kWhr)	9318.05	20890.07	2747.58	32955.70	32955.70	1042.69	7674.1 gallons	2325.89	5919.42	3398.64

Domestic Hot Water Usage Theory and Data

Energy inputs that enter the home include both solar thermal collection from evacuated tubes and that from wood gasification. During the months from mid june through early September there is no heat added to the floors, thus the only use for energy is for domestic hot water (DHW). Therefore it can be assumed that any solar thermal energy inputs that surpass that required to provide the needs for DHW are “dumped” via a heat dump; all solar thermal systems have a method of dumping excess solar thermal gain.

The water entering the home has a constant temperature of 6 C (43 F), and the water that is supplied to the DHW is tempered to 54.4 c (130 F). Using the following constants:

1 BTU = 0.00029307108333 kWhrs
1 BTU = 1 lb of water raised 1 ^{o}F

1 gallon of water weighs 8.34 lbs therefore it requires 8.34 BTUs to raise 1 gallon of water 1 F.

Formula:
Temperature rise (F) X Volume (gallons) X 8.34 BTU
Conversion to kWhrs:
Total BTUs X 0.00029307108333 = Total kWhrs energy
Source: Basic units of thermal measurement http://www.sun-volt.com/blog/2009/05/05/calculating-energy-needed-to-heat-water/

Actual Calculations:
(130F – 43F) X 1 gallon X 8.34 = 725.6 btus to heat 1 gallon of water from inlet to supply temp.
This number then gets subtracted off of the solar thermal inputs for the corresponding dates (June 23 2010 – September 7 2010, and June 2 -22 2011) when there is no requirement for the excess and thus nothing used for space heating; this number represents the "dumped" heat energy.

Table 5 – Domestic Hot Water calculations

	Gallons	kWhrs
Total	7674.1	1650.63
Avg per Week	147.6	31.74
Avg per day	21.0	4.52
Avg per person/day	4.2	0.90

Space Heating

At Eco-Sense all energy inputs are known, from wood and from solar thermal. We also can extrapolate as noted in Table 5, that certain energy can be subtracted out from the total inputs for DHW. We also can extrapolate the amount of heat that is collected in the summer months but not used and thus dumped. With this we can calculate the energy attributed to heating the household.

Wood + Solar Thermal – DHW – heat dump = Space heating.

Table 6 - Space heating calculations

Space Heating	(kWhr)
Total Wood inputs	20890.07
Total Solar Thermal	9318.05
Minus DHW	-1650.63
Minus Dumped	-3608.77

Total	24948.72

Solar PV Data

Gord to start on saturday

Carbon Footprint

Report by Christina Goodvin

Carbon Comparison for Similar sized home

Buildcarbonneutral.org Construction Carbon calculator for Earthen Homes

C.Goodvin, B.Eng., M.A.Sc., E.I.T.

Calculator Inputs:

Inputs

Total square feet of building equals 2500, in two stories, above ground. Primary structure of system selected as 'wood' as there is no option for earthen construction. Eco region selected based on map provided (Marine west coast forest). Predominate existing vegetation considered forest (protected zones). Installed vegetation would include native plants, living roofs, and extensive food producing annual and perennial edible gardens (selected as shrubland). The space footprint of the building installed is 1500 sq. feet. This coincides with the amount of 'disturbed area'.

Results

Inputs	Earthen home	Earthen home	Oak Bay home
Total Square Feet	2500	2500	2500
Stories Above Grade	2	2	2
Stories Below Grade	0	0	0
System Type	Wood	Concrete	Mixed
Ecoregion	Marine West Coastal Forest	Marine West Coastal Forest	Marine West Coastal Forest
Existing Vegetation Type	Forest	Forest	Forest
Installed Vegetation Type	Shrubland	Shrubland	Short grass or lawn
Landscape Disturbed (SF)	1500	1500	10, 000
Landscape Installed (SF)	1500	1500	2500
Embodied CO2	62 Metric Tonnes	115 Metric Tonnes	65 Metric Tonnes

Calculator shortfalls for earthen homes:

Building carbon model:

The primary construction system for aboveground earthen home is not available for selection. There is no estimate of carbon intensity ratios for cob in the calculator, something that could presumably be added in the future. An estimation made by selecting (non-certified) wood has significant differences in material properties from a cob mixture but is the calculator's closest representation of cob as a natural biomass on-site building material. Certified wood changes the calculation as it compensates for carbon released and acts as a carbon sink. Earthen systems presumably would also act as a carbon sink or have a negligible comparable carbon impact, as natural biomass materials have negative carbon intensity ratios [1].

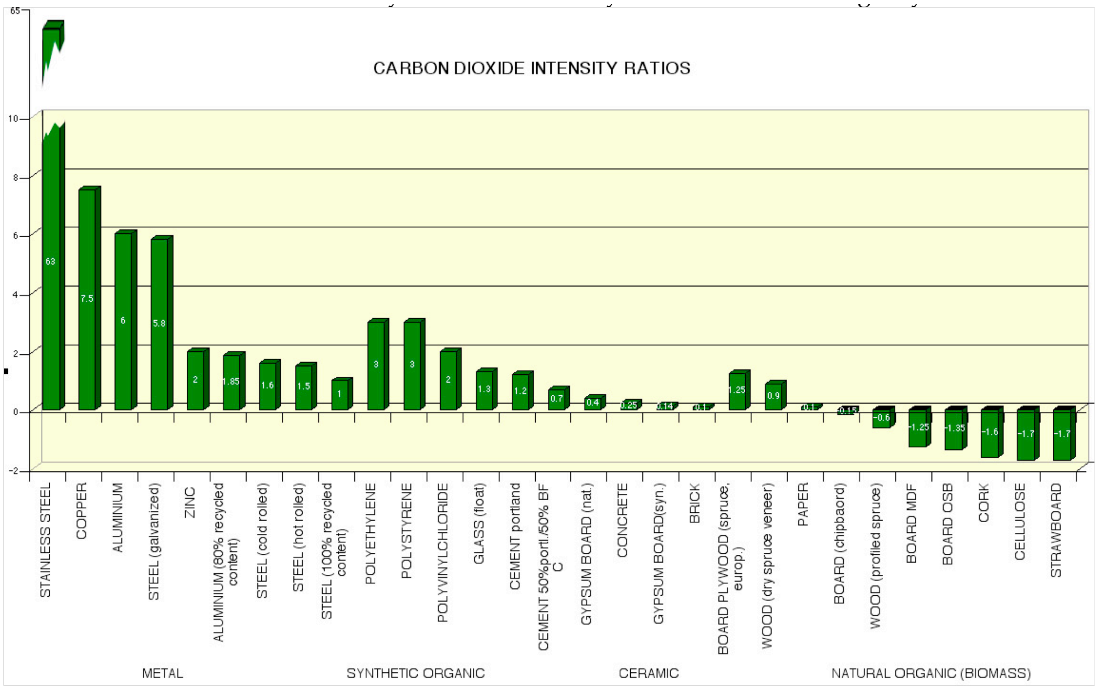


Figure 1 Carbon dioxide intensity ratios [2]

Note that a system selection of 'mixed' would presumably include large volumes of concrete and steel, which skews the estimation even farther then choosing wood, with an embodied CO2 estimate at 69 metric tonnes. If we were to choose concrete as a building material, for thermal mass similarities, the embodied CO2 estimate jumps to 115 metric tonnes. For comparison, we added our contemporary 1960s home in Oak Bay (drywall, wood frame, brick, concrete, lawn, etc.) and got a comparable 65 metric tonnes. The two homes could not be more different.

There is also no compensation in the calculator for substitution of low CO2 impact materials for high CO2 impact materials, or for the selection of high-recycled content materials. This is a particular factor in the consideration for the substitution of fly ash for Portland cement. Portland cement substitutes can significantly reduce the largest component of CO2 emissions in the life cycle of concrete production. The manufacture of portland cement accounts for about 95% of all CO2 emissions resulting from the production of concrete [2].

Landscape footprint:

What compensations are there to distinguish a contemporary build from an earthen home created practically on-site? How does the calculator compensate for the 2000 sq foot living roof made up with native plants suitable for climate location and plant life? Is there compensation for large vegetable gardens repurposed from a blasted rock dump that supports the family in residence? What compensations are included for self-sufficient levels of living, to include beehives, chickens, and other urban farming lifestyles created on the previously disturbed construction site? How does the calculator estimate restored site habitat? Though the calculator landscape data is for soil organic carbon and does not include above ground biomass, there should be compensation for restored soil habitat.

Total carbon footprint:

Since the embodied CO_2 calculator's purpose is presumably used as a measure to estimate the global warming potential of construction materials, it seems the calculator falls drastically short of the capability to produce a number for earthen materials used: earth walls, floors, living roof, longevity, less wood, high flyash concrete, home made paint, lime plaster, earth plaster, virtually no caulking, natural materials, very little plastic. Noted about calculator: Tenant improvements, interiors or furniture, fixtures or equipment have not been included in version 0.01.

Calculator principles:

The principles behind the calculator suggest a change to a 'Reduce, Renew, and Offset' lifestyle. The current version of the calculator does not compensate for the embodiment of this philosophy in many natural homes, in this instance in particular the Baird Earthen Cob home, where the 'purchase' of carbon offsets in unnecessary. The Baird home has used less to build less, protects and restores the natural ecosystem, is built smart and built efficiently. They use renewable energy, have restored or significantly improved disturbed sites to return to native ecosystems, use natural building materials, and have incorporated recycled and recyclable materials. This has not been reflected in the construction carbon calculator result.

Note on Life Cycle Balancing used in calculator:

The conventional building data takes into account site excavation, shell and core (structural systems, building envelope and building systems). The building data is based on Life Cycle Balancing and is not applicable to earthen homes. The carbon intensity factors for the calculator are as follows: Shell Known - 12%, Shell Unknown - 12%, Service Systems - 22%, Service Sector - 14%, Substructure Known - 2%, Substructure Unknown - 3%, Other/ Miscellaneous - 5%. Are these suitable for earthen homes?

The carbon dioxide intensity ratio (CDIR) is defined here as the ratio between the upstream CO_2 impact (emissions minus storage) of a material and the weight of the material.

CDIR = (CO_2e – CO_2s)/material end use weight where C O2 e = the weight of upstream C O2 emissions and C O2 s = the equivalent weight of C O2 stored as carbon in the mass of the material. A material with a positive CDIR is a net CO_2 source and one with a negative CDIR is a net CO_2 sink.

Also, a material's initial embodied CO_2 and GWP is not the whole story of its environmental sustainability. It's necessary to look beyond that in order to measure a building's true environmental impact. Over 50% of the UK's carbon emissions result from the energy used to heat, cool and light buildings. Over the life of a building, the operational CO2 emissions are far higher than the embodied CO2 of the material used to build it. The whole-life performance and energy consumption of a building are, therefore, vitally important factors to consider when evaluating the sustainability of construction materials. [3]

Upstream CO2 emissions (The upstream phase of processing and manufacturing building materials and products causes enormous off-site impacts prior to the building's use) Upstream CO2 emissions are roughly 5 times greater than direct emissions (for construction of the building) and 10-20 times greater than the annual operation (use) of the building. [1]
Some natural organic or biomass materials are net upstream CO2 sinks. In general, the denser the biomass material, the greater the carbon content and the greater the CO2 accumulation [2].

References

[1] MacMath, R. and P. Fisk III. 1999. *Life Cycle Balancing: Building Shell, Interiors, & Furnishings Sub-Systems: Nursing and Biomedical Sciences Building.* The University of Texas at Houston Health Sciences Center.

[2] MacMath, R. and P. Fisk III. 1999. *Carbon Dioxide Intensity Ratios: A Method of Evaluating the Upstream Global Warming Impact of Long-Life Building Materials.* Center for Maximum Potential Building Systems; Austin, TX.

[3] http://www.building.co.uk/comment/set-for-life/3083452.article

Carbon Calculation as per inputs from the Environmental Agency and Green Footstep

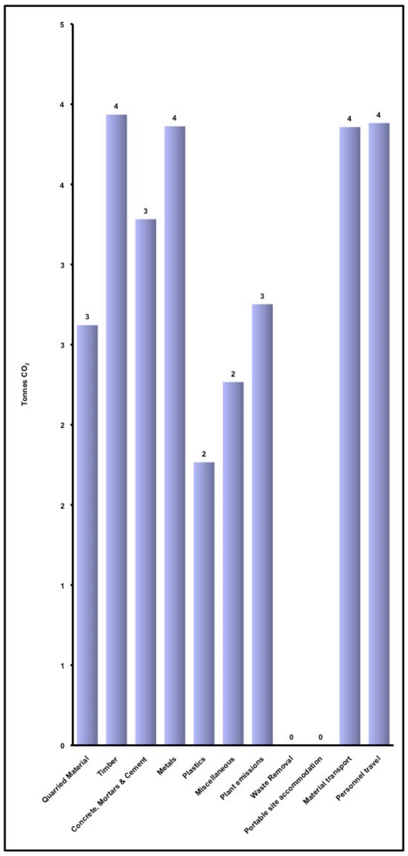
Title of option:

Construction cost: 187,000

Total Carbon Footprint: 28 tonnes fossil CO_2

Other factors which may affect CO_2 footprint

Some aspects that are not accounted for by this calculator include the re-planted lands, soil building, living roofs. The clay that was used in the cob walls was diverted from a longer travel distance, as it is part of a waste stream, and by diverting the transport to the site, a shorter distance, some co2 was decreased. In the concrete/cement section, 40% flyash was used, based on total concrete of 21 m3, 11844 lbs of cement/flyash was used in the calculator. For Straw, 8.6 kg of carbon is sequestered for every 25 kg of straw, thus at 1800 kg of straw, a reduction was added of 36% or minus 0.36 tCO2/tonne.



Environment Agency

Sub-totals	tonnes CO2	%
Quarried Material	2.6	9%
Timber	3.9	14%
Concrete, Mortars & Cement	3.3	12%
Metals	3.9	14%
Plastics	1.8	6%
Miscellaneous	2.3	8%
Plant emissions	2.8	10%
Waste Removal	0.0	0%
Portable site accommodation	0.0	0%
Material transport	3.9	14%
Personnel travel	3.9	14%

Significant materials (figures include transport to site)		
Horse Manure	0.000	tonnes CO2
Reclaimed/recyled wood	0.010	tonnes CO2
Soil	0.744	tonnes CO2
Sand	**3.768**	**tonnes CO2**
High Density Polyethylene (HDPE)	0.662	tonnes CO2
Stone gravel/chippings	1.075	tonnes CO2
Quarried aggregate	0.823	tonnes CO2
Sawn Softwood	**2.712**	**tonnes CO2**
Gas	0.049	tonnes CO2
Electricity	**2.703**	**tonnes CO2**

The accuracy of individual values is unlikely to be better than +/-5%. As a consequence of using default factors and estimated tonnages, carbon footprints obtained from this calculator might be expected to be within +/-25% of the true value. Given the range of values associated with certain materials (cements for example), default values may give results that are out by 100% or more. Local data should be used where available.

GREEN FOOTSTEP

YOUR BUILDING, YOUR CARBON, AND WHAT YOU CAN DO ABOUT IT

Rocky Mountain Institute

REPORT

Project Name:	Eco Sense with EA input
Location:	Canada, North America, NORTH AMERICA
Created by:	Gord Baird
Date:	Aug 22, 2010

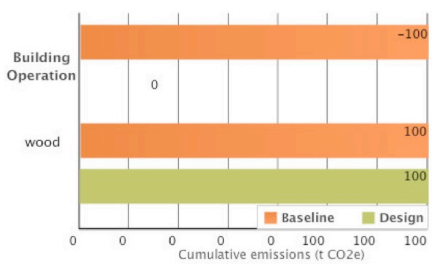
Your building will consume 5 kBtu per sq. ft. of energy each year in order to operate. Based on the mix of fuels used at the building and those used to create electricity in Canada, North America, NORTH AMERICA, this amount of energy translates to 4 t CO2e of emissions each year (including non-building operational emissions, if applicable). Your total annual offset emissions, based on your amount of on-site renewable energy and off-site carbon investments, is equal to 2 t CO2e each year, which yields a net annual operational emissions of 2 t CO2e.

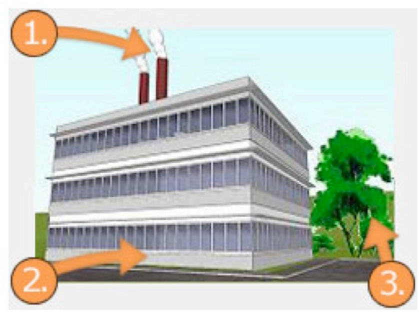
How do the emissions from this project translate to climate change? The total cumulative emissions of your building over its estimated lifetime is 260, which is a -19 percent reduction from the baseline you defined for your project. These emissions will result in a net increase in the atmospheric concentration of greenhouse gas. In order to avoid sea level rise above one meter and other effects of climate change, we need to stop increasing and stabilize this concentration of greenhouse gas at 450 ppm. (This information is based on the IPCC AR4 Synthesis Report, found at www.ipcc.ch.)

DATA SUMMARY

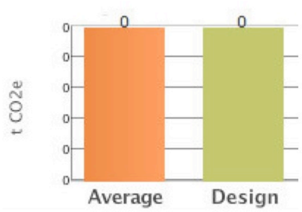
Cumulative Emissions Over 25 Years

1. Operational Emissions - 25 Years

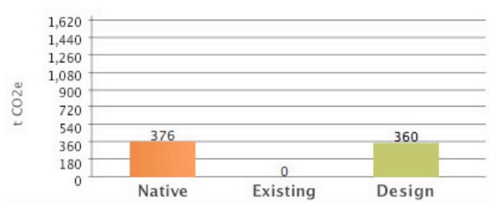




2. Embodied Emissions from Construction



3. Average Site Carbon Storage



Does your building meet the Architecture 2030 Challenge?	YES

[1] http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/databases.cfm
[2] Insolation data was collected across three weatherstations surrounding the Eco-Sense home, inclusive of Eagle View Elementary, Cal Revelle Nature Sanctuary and East Highlands Firehall. This data was supplied by UVIC.
[3] The average heating degree day for the area is 2902 HDD
Report: Roland V. Wahlgren "Heating/Cooling Degree-Day Seasonally in British Columbia." BC Hydro Customer Information Management – Load Analysis Jan 2010.

[4] The data collected from the University Of Victoria's regional weather stations for the two closest spots show that the HDD for the period of research was 3307 HDD, which translates into a 14% increase in HDD for the region.
HDD for Cal Revelle Nature Sanctuary: http://www.victoriaweather.ca/hdd.php?id=71&year=2011
HDD for East Highlands Firehall: http://www.victoriaweather.ca/hdd.php?id=99&year=2011&action=See+Data

[5] Statistics Canada 2006 census http://www40.statcan.gc.ca/l01/cst01/famil53c-eng.htm
[6] The family consists of Gord and Ann, their two children and Ann's parents. The children spend half time at the Eco-Sense home- due to this the number of people is averaged to 5.

[7] Eco-Sense uses LP gas for cooking, canning and preserving food. Unlike most homes, 80% of the food for on average three people is provided onsite, without the reliance on embodied energy found in conventional foods bought at the grocery store. 300 lbs of LP gas is used per year, with an energy footprint of 1894.53 kWhr. To account for the sheer volume of processed and preserved foods, 1/3 of this number is estimated to be the embodied energy of preserving. This leaves a figure of 1263 kWhr allocated for conventional food prep.
[8] Eco-Sense uses LP gas for cooking, canning and preserving food. Unlike most homes, 80% of the food for on average three people is provided onsite, without the reliance on embodied energy found in conventional foods bought at the grocery store. 300 lbs of LP gas is used per year, with an energy footprint of 1894.53 kWhr. To account for the sheer volume of processed and preserved foods, 1/3 of this number is estimated to be the embodied energy of preserving. This leaves a figure of 1263 kWhr allocated for conventional food prep.
[9] Source is a comprehensive report prepared by Christina Goodvin on the carbon footprint of the Eco-Sense home for the Living Building Challenge.
[10] Firewood usage. Like all fuels, wood is essentially carbon. Burning it emits carbon dioxide, and growing it absorbs carbon dioxide. A new tree absorbs the carbon dioxide emitted by burning an old tree. But there is a time delay of 25-50 years. Given that we need to reduce global CO2 emissions in the next 10-20 years, this time delay for re-absorption is too long. Therefore in this calculator wood is not considered carbon neutral, but you are only "charged" for half the emissions produced by burning it.
If you procure wood by the tonne or kg, enter the figures in the table below. (1 tonne = 1,000 kg.. If you obtain wood by the "load" and the weight is not known, it is possible to estimate your usage. I would guess that an average stove or Rayburn uses 10kg of wood in an evening or half a day. If you run your stove every evening for half the year (180 evenings), you burn 1,800kg per year. Using this as a benchmark, estimate your wood use and fill in the table.

	kg
kg used per day	10.425
Days use per year	365
Total kg used per year	3805.1250000000005
Conversion factor	1.779
CO2 emissions	6769
Half charge	3385

Total Wood CO2 emissions 3385kg

[11] Statistics Canada : http://www40.statcan.ca/l01/cst01/manuf03c-eng.htm ,