Life Cycle Assessment of Log Wall and Timber Frame Systems in British Columbia

Notice to Reader: *This document is a summary presentation of the findings published in "Life Cycle Assessment of Log Wall and timber Frame Systems Produced in British Columbia", prepared by* ***Athena Sustainable Materials Institute*** *in May 2012 and is not meant to replace the full report. Copies of the full report may be obtained from the resource section of the BC Log & Timber Building Industry Association Website www.bclogandtimberbuilders.com or by contacting the Athena Sustainable Materials Institute at http://www.athenasmi.org/*

Summary of the LCA Report

In order to quantify the environmental qualities of log and timber frame construction, a Life Cycles Assessment (LCA) of log and timber frame construction was completed by the Athena Sustainable Materials Institute with the results published in May 2012.

The study was completed in accordance with international standards on LCA, ISO 14040, ISO 14044 and ISO 21930. The study was driven by the desire to better understand the environmental footprint of log and timber frame products and to see that information published in Athena's EcoCalculator LCA Tool.

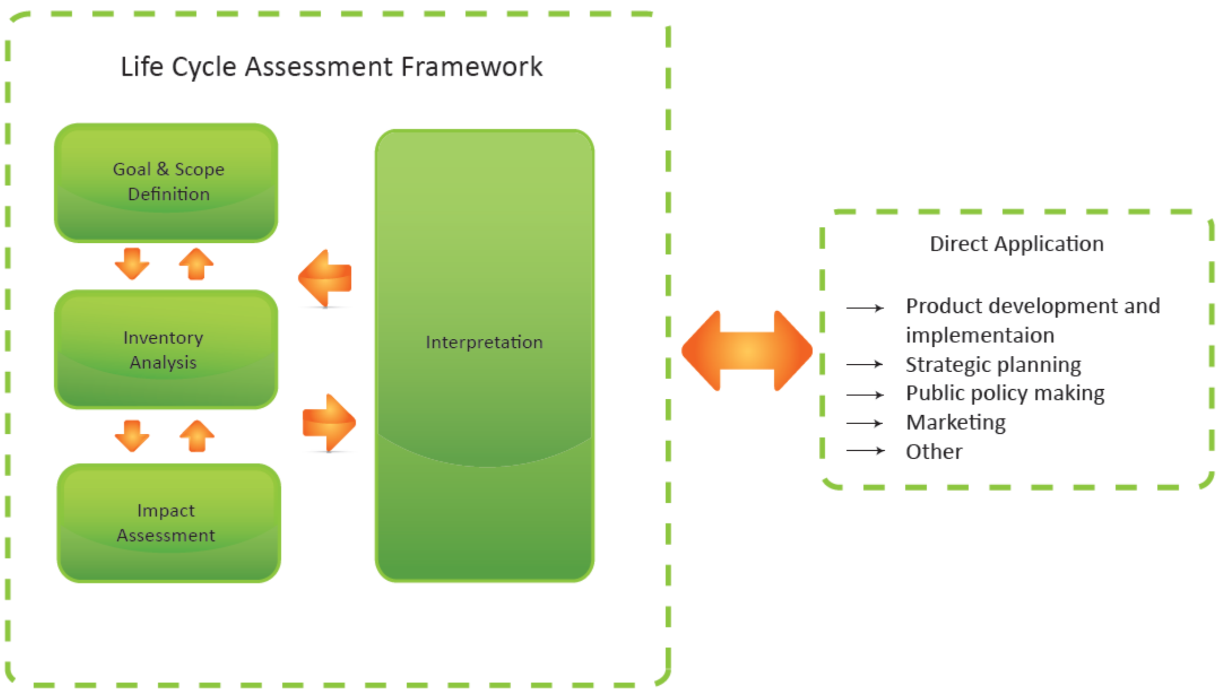

Figure 1: Stages of an LCA as per ISO 14044:2006

The Athena Institute completed a cradle-to-grave assessment determining the life cycle of three product systems were assessed in this study with a functional unit defined as:

1. Handcrafted Log Wall: Cradle-to-grave life cycle of 100 Square Feet handcrafted log walls (18 inch diameter); manufactured and installed at construction site in BC and then maintained for a service period of 60-years.
2. Milled Log Wall: Cradle-to-grave life cycle of 100 square feet milled profile log walls (8 inch diameter); manufactured and installed at construction site in BC and then maintained for a service period of 60-years
3. Timber Frame: 1000 board feet heavy timbers; manufactured and installed at construction site in BC and then maintained for a service period of 60-years.

The carbon sequestered in the three product systems was also assessed as a part of this study.

The life cycle impacts of the three functional units were assessed across a set of impact indicator and cumulative energy demand (fossil, nuclear and renewables) and weighted resource use were also calculated for two product life cycles.

The primary Life Cycle Inventory (LCI) data for this study was collected from 6 BC facilities, representing the various product types, for the reference year 2011. Plant personnel provided allocated data for each of the gate-to-gate product systems considered in the scope of the systems.

For other ancillary or process material, such as the production of chemical inputs, fuels and power, secondary data from commercially available LCI databases were deemed acceptable and used.

It is important to note that the impacts described by an LCA are estimates of relative and potential impacts, rather than direct measurements of real impacts.

The approach adopted by the Athena Institute was to survey a number of resource extraction and environmental specialists across Canada to develop subjective scores of the relative effects of different resource extraction activities. The scores reflect the expert panel ranking of the effects of extraction activities relative to each other for each of several impact dimensions. The scores were combined into a set of resource-specific index numbers, which are as weights to the amounts of raw resources used to manufacture each building product. The Weighted Resource Use values reported by the Impact Estimator are the sum of weighted resource requirements for all products used in each of the designs. They can be thought of as “ecologically weighted pounds or kilograms”, where the weights reflect expert opinion about the relative ecological carrying capacity effect of extracting the resources.

Life cycle impact assessments were completed to measure the impact of each of the three product types for each of the following Impact Indicators to determine the total energy used which is further defined to identify the amounts of Fossil, Nuclear and Renewable energy used over the life cycle of the product

- Global Warming
- Acidification
- Respiratory effects

- Eutrophication
- Smog
- Ozone Depletion
- Weighted Resource

For **handcrafted log walls**, the results indicate that the manufacturing portion of the life cycle is the greatest contributor to impacts in all categories except weighted resource use and respiratory effects. The logging process consumes the greatest resources because this process is the point in the life cycle where wood resources are extracted from the environment. The respiratory effects in the staining portion of the life cycle is caused by nitrogen oxide emissions generated in propylene manufacture, which is a precursor to the acrylic portion of the stain.

Besides weighted resource use, the logging portion of the life cycle is a small contributor to impacts in all categories. The steel fasteners and gaskets, as well as the end of life processing, are similarly small overall contributors to the life cycle impacts.

The delivery and construction of the log walls accounts for roughly 20% of the life cycle global warming impacts. This amount is somewhat higher than is typical in residential construction due to the massive nature of the log walls that requires significant transportation burdens and the use of a crane to hoist the logs into place at the construction site.

The results for the **milled profile wall** are similar to the handcrafted wall. Again, the cant milling and manufacturing portion of the life cycle is the greatest overall contributor to life cycle impacts, with the exception of the respiratory effects of the stain and the resource use attributed to the logging process.

The logging, delivery, and construction portions of the life cycle cause less impacts in the milled profile log wall life cycle than in the life cycle of the handcrafted log wall. This is due to the fact that the milled profile log wall consumes less raw material and weighs less than half as much as the handcrafted wall. The additional electricity consumed in the manufacturing portion of the life cycle as compared to the manufacturing of the handcrafted wall is inconsequential since the grid in BC is based entirely on hydro power which is a minor contributor to the reported environmental impacts.

For **Heavy Timbers,** the timber milling process is the greatest cause of impacts in the life cycle, with the logging causing less than 10% of impacts in all categories except weighted resource use. It should be noted that while the focus of this LCA was not to identify the overall scale of environmental impacts since no comparisons are involved, the overall impacts of all three products, and particularly the heavy timbers, is quite low across the board.

Further analysis was completed to determine the Sensitivity Impacts of:

- Transportation to Construction Sites Outside of BC
- Kiln Drying of Milled Profile and Timber Frame
- Staining

Transportation

The functional unit in this study was based on the construction of the log walls and timber frames in British Columbia. The results may be translated to other locations by considering the impacts of transporting the various products to construction sites across North America, Asia, and Europe.

The transportation impacts are significant in terms of the overall life cycle impacts. Transporting the log walls 1000 km by truck increases the global warming impacts between 37% and 68% for the various products. Considering the fact that the Rocky Mountain region of the United States is a significant market for BC log and timber products, this means that shipping a log wall from Vancouver to Denver (2,400 km) via truck more than doubles the global warming impacts of all three products. Similarly, a train shipment across the continent to the east coast (4,500 km) or a trans-atlantic shipment (5,500 km) would increase impacts by greater than 50% and by as much as 100%. It should be noted that these transportation impacts are only calculated in relation to the overall impacts of the rest of the life cycle which are generally quite low and any consideration between alternative materials should similarly include shipping as a portion of the life cycle.

Kiln Drying of Milled Profile and Timber Frame

The baseline case in the analysis excluded kiln-drying as the industry's standard practice is to use air-dried material – often from standing dead timber. The handcrafted log walls almost exclusively use air-dried material due to the difficulty of kiln drying whole logs, but the milled profile log walls and timbers are often sold as kiln-dried.

The kiln drying process modestly increases the impacts of the milled log walls and timber products. Additional smog and weighted resource use are caused by the use of wood fuel in the drying process that causes additional nitrogen oxide emissions and wood resource consumption.

Staining

The baseline scenario assumed staining every 6 years whereas a fastidious log home owner may choose to stain more often than this

The increased stain frequency doubles the contribution of this portion of the life cycle, adding roughly 20% in additional global warming impacts. This is noteworthy for portions of the log home and construction sites that are subject to above-average weathering conditions. It may similarly be concluded that a less maintenance-conscious home owner, and one in a less demanding climate, may stain less than once every 6 years and with less than 3 coats each time and subsequently reduce impacts (although potentially causing greater replacement and repair frequency).

Conclusions

The impacts of the three products are generally driven by the manufacturing portion of the life cycle. The stain is also a significant driver of impacts, accounting for roughly 20% of global warming impacts in the two log wall life cycles. The logging, construction, steel and gasket use, and end of life processing are less significant in terms of overall impacts.

The sensitivity analysis revealed that the results are highly sensitive to the transportation distance and mode of transportation. Shipping the products via truck to a Rocky Mountain US city such as Denver roughly doubles the global warming impacts, as does shipping the materials via train across the continent or via ship to Asia or Europe. The kiln drying and staining frequency, while significant, were less influential to overall impacts.

The final consideration of this analysis is to compare the carbon sequestration with the life cycle impacts. Table 7 shows the net carbon footprint of the three products that includes both the net carbon sequestration as shown in Table 7 and the greenhouse gasses from the rest of the life cycle. This result is also shown graphically in Figure 7.

Table 1: Carbon Sequestration Balance for Log and Timber Products

	Biogenic Flows per ODKG (kg CO2e)	100 Sq. Ft. Handcrafted Log Wall (kg CO2e)	100 Sq. Ft. Milled Profile Log Wall (kg CO2e)	1000 Board Feet Timbers (kg CO2e)
Baseline Sequestration	-1.83	-2546.98	-1131.99	-1218.73
Direct Emissions	0.20	283.69	126.08	135.74
Emissions from flaring	0.12	165.04	73.35	78.97
Emissions from energy recovery	0.28	385.10	171.16	184.27
Prevented nat. gas emissions	-0.18	-243.79	-108.35	-116.65
Net Carbon Sequestration	-1.41	-1956.93	-869.75	-936.39

It is clear that the overall carbon sequestration benefits of the three products far outweigh the greenhouse gas emissions caused by the rest of the life cycle. In the case of the handcrafted log walls that cause very little impacts relative to the mass of the product, the carbon sequestered in the wood is greater than 10 times the greenhouse gas emissions from the rest of the life cycle.

Table 21: Net Carbon Balance for Log and Timber Products

	100 Sq. Ft. Handcrafted Log Wall (kg CO2e)	100 Sq. Ft. Milled Profile Log Wall (kg CO2e)	1000 Board Feet Timbers (kg CO2e)
Life Cycle Greenhouse Gas Emissions	183.35	218.08	123.49
Net Carbon Sequestration	-1956.93	-869.75	-936.39
Net Carbon Balance	-1773.59	-651.66	-812.90

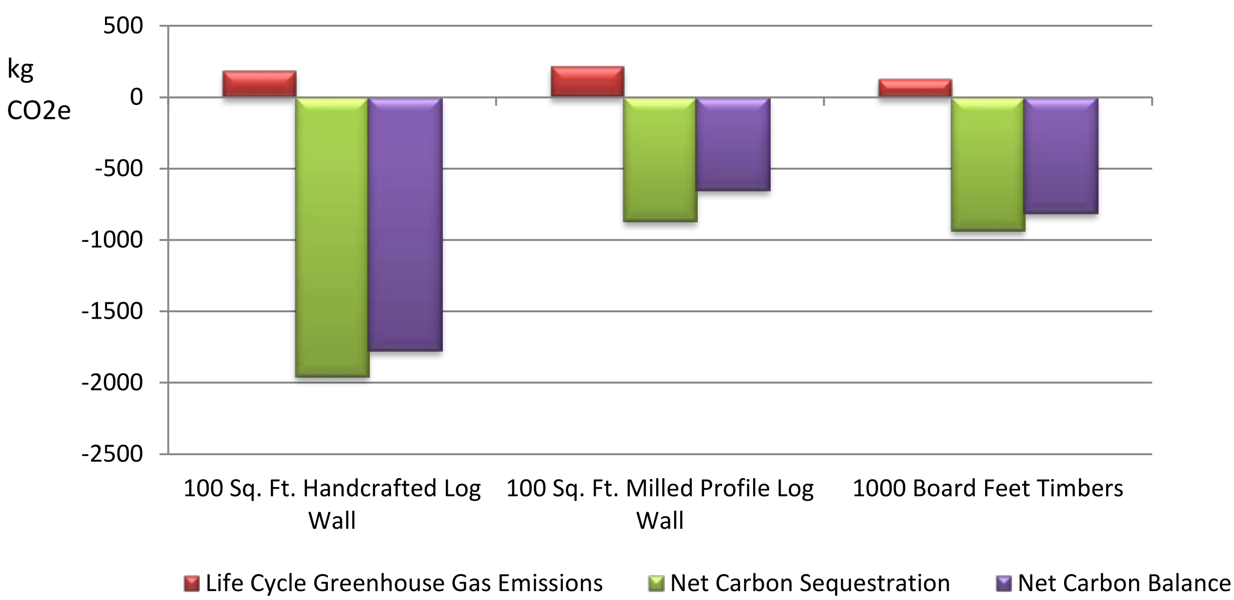

Figure 7: Net Carbon Balance for Log and Timber Products

Limitations

The sensitivity analysis revealed several areas of uncertainty in the study. First, the construction sites were limited to the BC region and assumed that the materials were transported 200 km to the construction site. To expand the analysis to the rest of the BC log and timber industry's sales regions throughout the world, the mode of transportation would first need to be established and the impacts recalculated. The underlying data to derive these balances are available in the sensitivity analysis which identified this as a major area of sensitivity in the model.

The stain and kiln-drying are also sources of uncertainty in the model. The kiln-drying is less influential to overall impacts, but the stain frequency is a significant source of uncertainty as it is reliant on the tendencies of individual home owners and other burdens that may be site specific and even vary within a building depending on orientation.

The results indicate that the manufacturing portion of the life cycle is the greatest contributor to impacts in all categories except weighted resource use and respiratory effects. The logging process consumes the greatest resources because this process is the point in the life cycle where wood resources are extracted from the environment. The respiratory effects in the staining portion of the life cycle is caused by nitrogen oxide emissions generated in propylene manufacture, which is a precursor to the acrylic portion of the stain.

The overall impacts are quite low for all of the products that were assessed in this LCA as the life cycle draws heavily on BC electricity which is generated by low impact hydropower. **The carbon balance that includes carbon sequestration also identifies that the log walls have the potential to be well beyond carbon neutral and result in an overall carbon sink.** This gives the BC LTBIA significant leverage to push for the incorporation of life cycle impacts as a justification for alternative compliance or exceptions with regards to thermal performance based standards and building codes.