ENVIRONMENTAL PRODUCT DECLARATION

NORTH AMERICAN LAMINATED STRAND LUMBER

AMERICAN WOOD COUNCIL
CANADIAN WOOD COUNCIL

Laminated strand lumber (LSL) is created by layering dried and graded strands together with moisture resistance resin and sawn into specific sizes.

The American Wood Council (AWC) and Canadian Wood Council (CWC) represent wood products manufacturers across North America. The AWC and the CWC are please to present this Environmental Product Declaration (EPD) for North American laminated strand lumber.

EPDs enable comparison between products but do not themselves compare products. EPDs can only be used for comparison between different building products and systems if they have been assessed on the basis of the same functional unit and service life using the same Product Category Rule. Information in this EPD is provided using a declared unit and shall not be used for comparison.

The EPD includes life cycle assessment results for all processes up to the point that laminated strand lumber is packaged and ready for shipment at the manufacturing gate.

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ENVIRONMENTAL PRODUCT DECLARATION

AMERICAN WOOD COUNCIL

Canadian Wood Council / Conseil canadien du bois

North American Laminated Strand Lumber (LSL)
North American Structural and Architectural Wood Products

According to ISO 14025 and ISO 21930

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	American Wood Council
DECLARATION NUMBER	4787193543.101.1
DECLARED PRODUCT	Laminated Strand Lumber
REFERENCE PCR	FP Innovations. 2015. Product Category Rules (PCR) for preparing and environmental Product Declaration (EPD) for North American Structural and Architectural Wood Products. https://fpinnovations.ca/ResearchProgram/environment- sustainability/epd-program/Documents/pcr-v2.pdf.
DATE OF ISSUE	February 24, 2016
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	FP Innovations
	PCR review committee
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This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas Gloria, Industrial Ecology Consultants

Environment

Description of Industry and Product

Description of North American Laminated Strand Lumber Industry

The North American forest products industry is a major contributor to both the United States and Canadian economies. Wood manufacturing jobs, including those required to produced laminated strand lumber (LSL) serve as the primary economic drivers in rural areas of both countries. In 2013, North American LSL manufacturers production capacity was over 11.2 million cubic feet (316 thousand cubic meters).

LSL is part of a family of structural composite lumber (SCL). LSL is a growing segment of the SCL industry and is used in various applications that take advantage of its uniform engineering properties. Most commonly LSL is used in headers and beams, wall stud applications, roof beams and rafters, truss chords, rim board, and stair stringers. The material properties of LSL are dependent on the density of the panel, the strand species, and the orientation of strands. LSL can be produced from forest resources that are less suitable for other building materials in that it can and is made from smaller diameter, low quality trees. The primary species used in North America are a mixture of aspen, birch, and maple. Two LSL manufacturers contributed production data from the United States and Canada. No LSL manufacturers were in operation in Mexico (Table 1).

Table 1. North American Laminated Strand Lumber Manufacturers (2013)

Manufacturer	City	State/Province, Country
Louisiana-Pacific Corp	Houlton	Maine, United States
Weyerhaeuser	Kenora	Ontario, Canada

Description of Laminated Strand Lumber Product

The manufacturing process of LSL begins by cutting small veneers directly from whole logs. The veneers (strands) are dried to remove moisture and then sprayed using a waterproof "formaldehyde free" adhesive which bond the strands together under steam and pressure. At the end of production, LSL has a final moisture content of 7 to 10 percent (dry basis). Production is measured on volume (cubic feet (ft^3) or cubic meters (m^3)) at varying thicknesses, widths, and lengths.

The product profile presented in this EPD is for a declared unit of 1 cubic meter of LSL. One cubic meter of average North American LSL weighs 570.22 kg excluding moisture. The product composition is presented below and represents the weighted average of the resin and wax used in LSL manufacturing.

- Wood: oven dry 533.22 kg (93.50%)
- Methylene diphenyl diisocyanate resin: 31.18 kg (5.99%)
- Wax: 2.88 kg (0.50%)

This EPD is based on LCA studies that considered the entire range of LSL product sizes and functions. For reference purposes, the results are provided for 1 cubic meter of finished product which is equal to 35.31 cubic feet.

North American Laminated Strand Lumber (LSL)
North American Structural and Architectural Wood Products

According to ISO 14025 and ISO 21930

Cradle-to-Gate Life Cycle of LSL

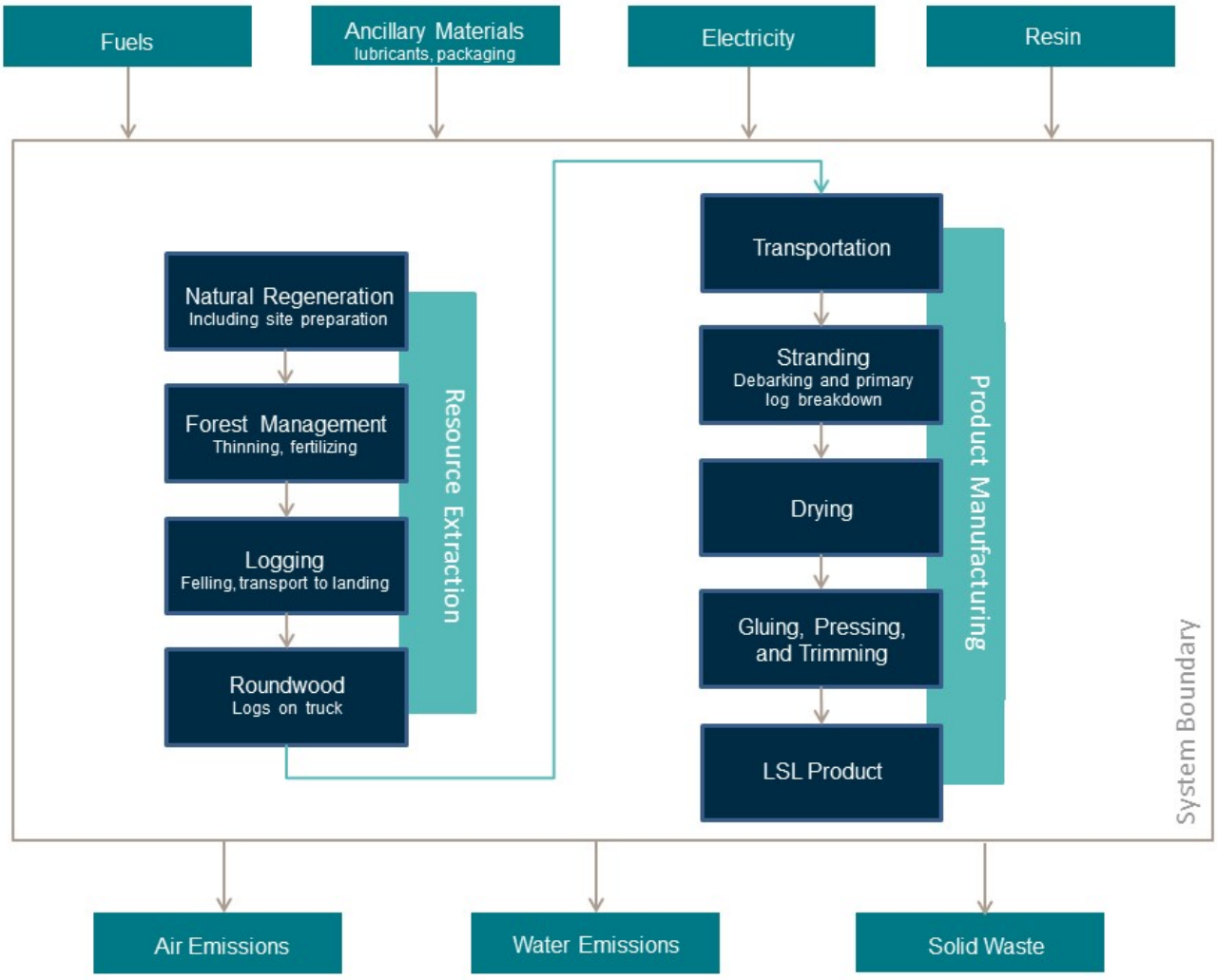


Figure 1 Cradle-to-gate system boundary for LSL

Forest Operations

The PCR requires that the production system include extraction of raw materials including reforestation activities. Therefore, the life cycle assessment of a wood product includes the energy use and emissions from all forestry operations which include plantation establishment, management, and harvesting. In the EPD for LSL, the cradle-to-gate product system begins with the establishment of a natural or managed forest by natural regeneration or planting of seedlings, respectively. The boundary also encompasses all forest management activities which may include site preparation, thinning, and fertilization.

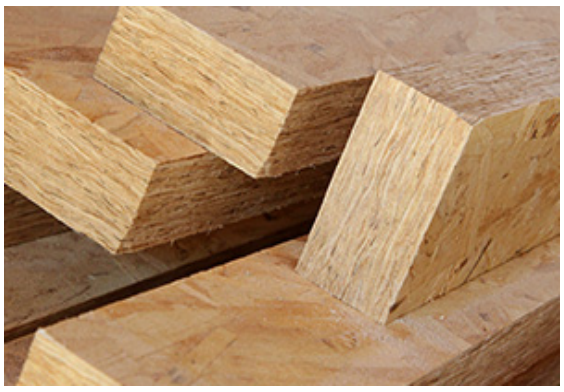
LSL Production

The LSL production phase begins with the transportation of the logs to the mill by truck. Once the logs reach the mill, the manufacturing process begins with a whole logs cut to length, de-barked, and submerged in conditioning ponds. Logs are then cut into strands, screened, dried to a control moisture content, bonded with non-formaldehyde resin, and pressed. Grade marks and logos are applied to the surface of each piece LSL. Finished boards stamped boards are coated with an edge-seal stacked in bundles and cut to specific lengths. These processes consume electricity drawn from regional grids, fossil fuels, and internally generated woody biomass.

Packaging of Laminated Strand Lumber

Laminated strands boards are stacked in bundles, wrapped, and strapped into finished units for short term storage or immediate shipping. Packaging materials can include recyclable polypropylene waterproof wrapping, plastic strapping, and cardboard to protect strapping from damaging boards. Wrapping material and strapping can vary between manufacturers. Wood spacers can be used between units for ease of transferring units using forklifts. Packaging materials represent less than 1.0 percent of the cumulative mass of the model flow.





Methodology of Underlying LCA

Business-to-business EPD and Cradle-to-Gate LCA

Business-to-business (B-to-B) EPDs include the life cycle of the product up to the point that the product has been manufactured and is ready for shipment. This is commonly referred to as a cradle-to-gate life cycle assessment. The cradle-to-gate processes included in this EPD are outlined in Figure 1. The use phase and end of life scenarios can be omitted in a B-to-B EPD.

This Type III environmental declaration is developed according to ISO 21930 and 14025 for laminated strand lumber. This EPD reports environmental impacts based on established life cycle impact assessment methods. The reported environmental impacts are estimates, and their level of accuracy may differ for a particular product line and reported impact. LCAs do not generally address site-specific environmental issues of related to resource extraction or toxic effects of products on human health. Unreported environmental impacts include (but are not limited to) factors attributable to human health, land use change and habitat destruction. Forest certification systems and government regulations address some of these issues. In this EPD the woody residues used in the production of LSL coming from Canadian and US forests are harvested under the applicable federal, provincial, and state laws. EPDs do not report product environmental performance against any benchmark.

Declared Unit

In accordance with the PCR, the declared unit for LSL is one cubic meter (m^3) which is equal to 35.31 cubic feet. The average density of North American LSL including resins and excluding moisture is 570.28 kg/m^3 oven dry. LSL produced in North America can have a 7–10 percent moisture content therefore the final weight of product will be variable.

System Boundaries

The system boundary begins with the planting, growth and harvest of trees in North American and ends with LSL packaged to leave the mill gate. The forest resources system boundary includes: forest regeneration and stand management, felling the trees, removing limbs, transportation of logs to landing, and cutting to shipping lengths. Excluded from forestry operations are maintenance and repair of equipment, and building and maintenance of logging roads, logging camps, and weigh stations. The transportation of logs from the woods to the mill is accounted for with the LSL manufacturing. The LSL production process includes log yard operations and primary log breakdown. Outputs include 1 m^3 of LSL ready to be shipped, air and water emissions, solid waste, and co-products.

Cut-Off rules

The cut-off criteria for flows to be considered within the system boundary are as follows:

- Mass – if a flow is less than 1% of the cumulative mass of the model flows, it may be excluded, provided its environmental relevance is minor.
- Energy – if a flow is less than 1% of the cumulative energy of the model flows, it may be excluded, provided its environmental relevance is minor.
- Environmental relevance – if a flow meets the above two criteria, but is determined (via secondary data analysis) to contribute 2% or more to the selected impact categories of the products underlying the EPD, it is included within the system boundary.

Data Quality

Precision and Completeness

Primary data on raw materials, energy, and emissions were provided by LSL manufacturing facilities, based on purchase inputs, production outputs, and reported process emissions. All upstream and downstream secondary data (e.g. forestry operations and fuel production) were drawn from publically available databases, primarily the United States Life Cycle Inventory (USLCI) database and other public LCI data sources. The LCA practitioners performed quality control on all secondary data sources to ensure completeness.

All inventory flows were modeled and no data were excluded due to application of the EPD cut-off criteria.

Consistency and Reproducibility

To ensure consistency, only primary data as provided by the LSL manufacturers, were used to model gate-to-gate LSL manufacturing processes. All other secondary data (upstream and downstream) were consistently applied and adaptations to the databases were documented in the LCA reports.

Reproducibility by third parties is possible using the background LCIs documented in the CORRIM and Athena reports.

Temporal Coverage

Primary data collected from the manufacturing facilities related to the product processes of interest are representative for the year 2013.

Geographic Coverage

The geographical coverage for this EPD is based on North American (NA) system boundaries for all processes and products.

Treatment of Biogenic Carbon

Biogenic carbon dioxide emissions were counted as global warming neutral in accordance with the PCR. Under this approach, the carbon dioxide emissions from the combustion of internally generated wood fuels are considered equal to the carbon dioxide uptake in the forest during tree growth.

Crediting carbon sequestration against the global warming potential was excluded as the long term carbon storage is dependent on gate-to-grave processes not considered directly in this EPD. The expected carbon sequestration for average end-use and end-of-life treatment is provided in the section on "Additional Information."

Allocation

An economic allocation was used in the LCA of laminated strand lumber. According to the PCR (FPInnovations 2015) if one or more co-products are generated during the production process, it is necessary to allocate the inputs and outputs using a standardized approach. The LCA on LSL follows the allocation rules which states that when the total revenues between the main product and co-products is more than 10%, allocation shall be based on the revenue [economic] allocation. The 10% rule is applied based on a per unit basis, in this case per m^3 of LSL.

Laminated strand lumber is a single-output process and thus no allocation was applied to the manufacturing gate-to-gate process. The wood fiber input (logs with bark) was also treated in this manner since the value of strands as the main wood fiber product far exceeded the other coproducts.

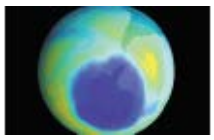
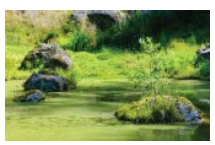
Data Collection and Calculation Methods

Primary data for the LCI was collected through surveys. This study relied almost exclusively on production inputs and emissions data provided by LSL producers in North America, with some secondary data from the USLCI database. All allocation was based on the value (economic allocation) of the products and co-products. Survey data were converted to a unit production basis of 1 cubic meter and a weighted average of input data was calculated based on production data.

Life Cycle Assessment Results

The life cycle impact assessment (LCIA) established links between the life cycle inventory results and the potential environmental impacts. In the LCIA, results are calculated for impact category indicators such as global warming potential and smog potential. These impact category indicator results provide general, but quantifiable, indications of potential environmental impacts. The various impact category indicators and means of characterizing the impacts are summarized in Table 1. Consistent with the requirements of the PCR, five impact categories are reported in Table 2. The TRACI 2 method was used to characterize the reported environmental impacts.

Table 2: Impact Assessment Categories

Impact Category Indicators	Characterization Model
Global Warming Potential 	Calculates global warming potential of all greenhouse gasses that are recognized by the IPCC. The characterization model scales substances that include methane and nitrous oxide to the common unit of kg CO_2 equivalents.
Ozone Depletion Potential 	Calculates potential impact of all substances that contribute to stratospheric ozone depletion. The characterization model scales substances that include CFC's, HCFC's, chlorine, and bromine to the common unit of CFC-11 equivalents.
Acidification Potential 	Calculates potential impacts of all substances that contribute to terrestrial acidification potential. The characterization model scales substances that include sulfur oxides, nitrogen oxides, and ammonia to the common unit of kgSO_2 equivalents.
Smog Potential 	Calculates potential impacts of all substances that contribute to photochemical smog potential. The characterization model scales substances that include nitrogen oxides and volatile organic compounds to the common unit of kg O_3 equivalents.
Eutrophication Potential 	Calculates potential impacts of all substances that contribute to eutrophication potential. The characterization model scales substances that include nitrates and phosphates to the common unit of kg N equivalents.

Cradle-to-Gate Impact Assessment

Modules included in the EPD are (Table 3): A1- Raw material supply, which includes resource extraction, A2 – Transportation of resource to LSL, and A3 – Laminated strand lumber production. The impact assessment results for LSL are shown in Table 4. This LCIA does not make value judgments about the impact indicators, meaning that no single indicator is given more or less value than any of the others. All are presented as equals. Each impact indicator summarizes a different group of environmental emissions based on their pathway to potential impact using units that are common within the group but not comparable between groups. For this reason the indicators should not be combined or added.

The results presented below indicate the potential impacts caused by the cradle-to-gate production of LSL. Ozone depletion was below 10^{-5} kg CFC eq. for both Forestry Operations and LSL Production and is thus not reported in the results. Water consumption was a total from the LCI as required by the PCR and includes all water withdrawals without netting out non-consumptive use. As a result, the total water consumption is a conservative value which may overstate the use.

Table 3. Life cycle stages included in the LCA.

Product stage			Construction process Stage		Use stage							End of life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = modules included in the study
MND = Module not declared

Table 4: Cradle-to-Gate Impact Assessment Results - 1 m^3 North American LSL				
Impact category Indicator	**Unit**	**Total**	**Forestry Operations**	**LSL Production**
Global warming potential	kg CO_2 eq.	310.28	29.31	280.97
Acidification Potential	kg SO2 eq.	2.41	0.14	2.27
Eutrophication Potential	kg N eq.	0.0709	0.0072	0.0637
Ozone depletion Potential	kg CFC-11 eq.	0.0000	0.0000	0.000
Smog Potential	kg O_3 eq.	34.05	3.26	30.79
Total primary energy consumption	**Unit**	**Total**	**Forestry Operations**	**LSL Production**
Non-renewable, fossil	MJ	4810.87	439.81	4371.06
Non-renewable, nuclear	MJ	1281.70	5.94	1275.75
Renewable, biomass	MJ	7574.23	0.03	7574.21
Renewable, other	MJ	165.83	0.85	164.99
Material resources consumption	**Unit**	**Total**	**Forestry Operations**	**LSL Production**
Non-renewable materials	kg	17.00	0.00	17.00
Renewable materials	kg	877.98	877.98	0.00
Fresh water	L	178.09	0.00	178.09
Non-hazardous waste generated	**Unit**	**Total**	**Forestry Operations**	**LSL Production**
Solid waste	kg	35.26	0.45	34.80



Impact Assessment Results by Life Stage

The two graphs below show the LSL manufacturing life cycle stage is the primary driver of impacts in the cumulative cradle-to-grave product system. Laminated strand lumber manufacturing consumes 91% of fossil fuels and 100% of biomass energy which drives the impacts in all categories.

Figure 2: Cradle-to-Gate Impact Assessment Results

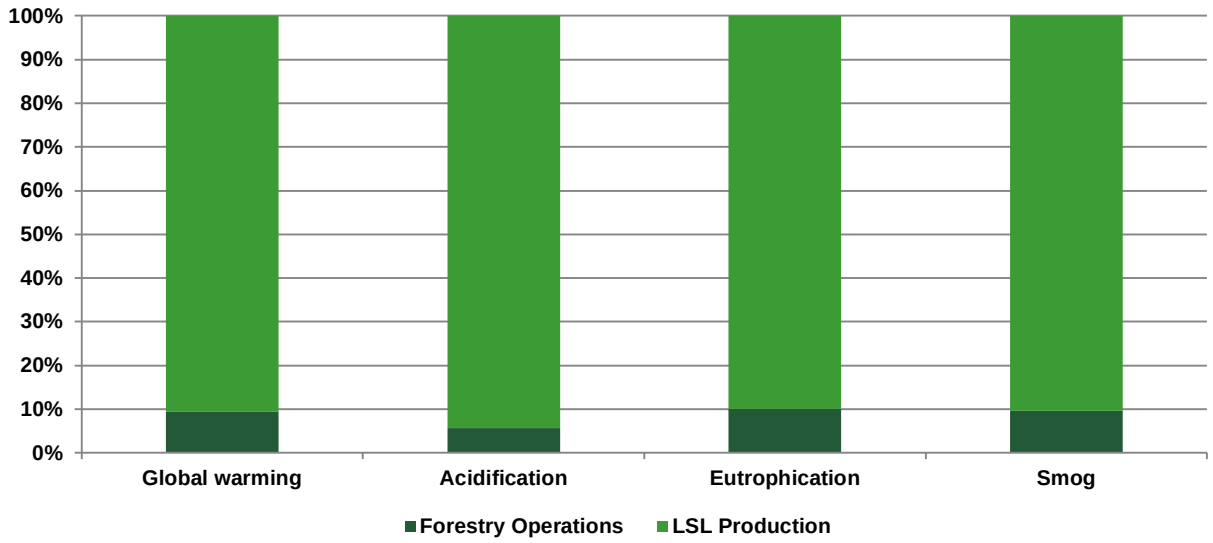


Figure 3: Cradle-to-Gate Energy Primary Consumption

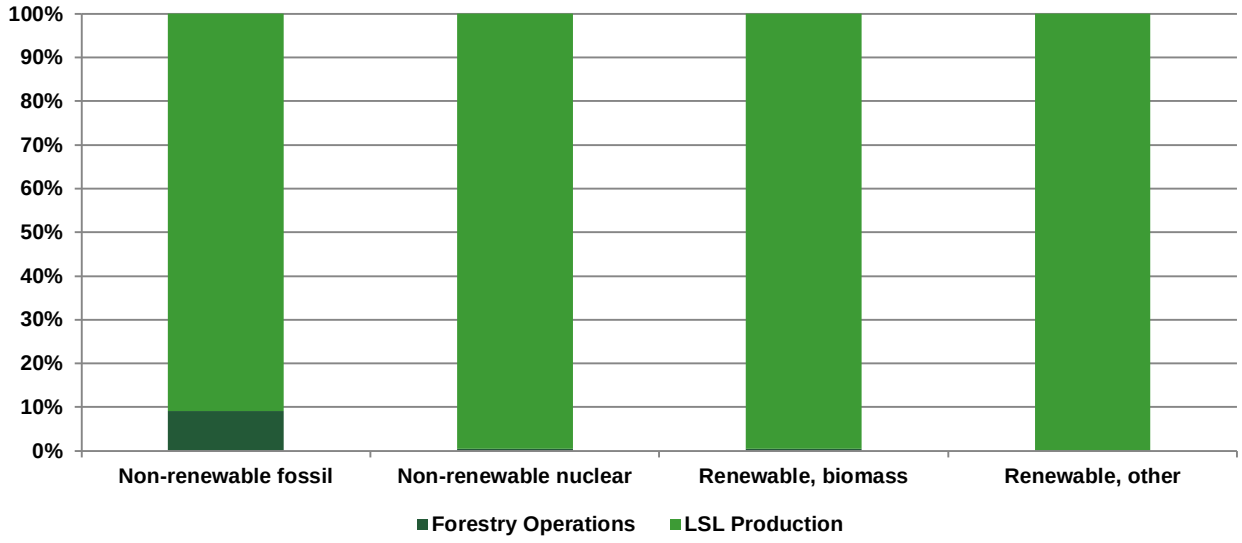


Figure 4: Cradle-to-Gate Energy Use

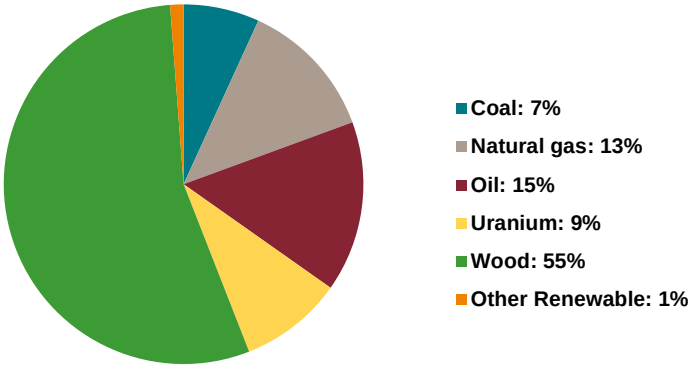


Figure 5: Forestry Operations Energy Use

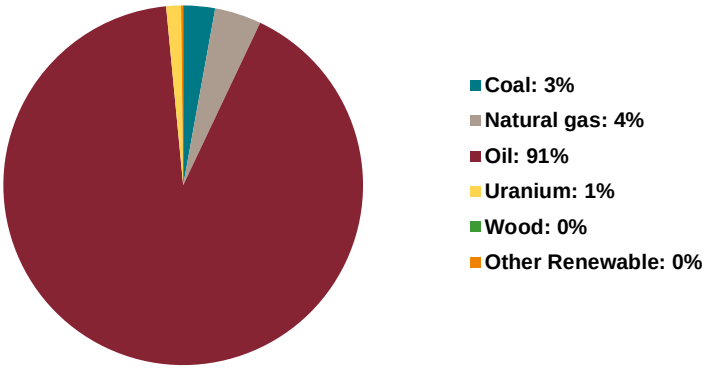
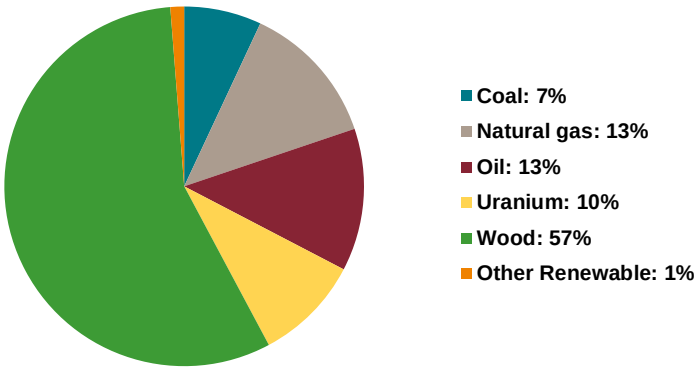


Figure 6: LSL Production Energy Use



Primary Energy Consumption by Resource

The three pie charts show the consumption of various primary energy required for the total cradle-to-gate, forestry operations, and LSL production life stages. The LSL production consumes the bulk of the energy consumption and is reflected in the total cradle-to-gate chart (Figure 4).

The forestry operations portion of the life cycle relies heavily on oil-based energy consumed mainly in the form of diesel used by heavy equipment during planting, management, and harvesting of the resource. Oil accounts for 91% of primary energy resources consumed in forestry operations.

More than half (57%) of the energy requirement in LSL manufacturing is met by renewable biomass energy. This translates to 55% in the cradle-to-gate biomass energy use. The biomass consumption is used in the drying of wood strands, pressing of panels, and heating log ponds during the winter months. Coal, natural gas, oil, and nuclear compose the remaining energy use. Other renewable (hydry, solar, wind, and geothermal) was less around 1% and is from electricity that is consumed throughout the cradle-to-gate product system.

The prevalence of renwable energy use in the life cycle of LSL means that 33% of the energy consumption is derived from fossil fuel sources. This means that LSL has a particulary low carbon footprint relative to the energy required for manufactuing.

Additional Information

Range of Applications

LSL is used primarily as structural framing (beams, headers, studs, and rim boards) in residential and commercial construction. As part of a growing group of structural wood products, LSL is classified into the SCL group of products.

The following lists the breakdown of SCL end uses in North America:

- New non-residential construction: 13%
- New single family residential construction: 38%
- New multifamily residential construction: 16%
- Other end-uses: 33%

Source: American Panel Association, APA, 2015

Carbon Sequestration

This PCR requires that carbon sequestration may only be credited to the product if the end-of-life fate of that carbon is considered in the LCA study. FPInnovations (FPI) has recently published a carbon sequestration calculation tool that estimates the emissions from typical end-of-life treatment of wood products that includes recycling, combustion, and landfilling. The carbon sequestration in the product at the manufacturing gate serves as the basis for such an analysis and is as follows (all conversion factors and assumptions are documented in the carbon tool):

1 m^3 LSL = 533.22 oven dry kg = 266.61 kg Carbon = 977.57 kg CO_2 eq.

This initial carbon sequestration may then be considered against its emission as the LSL product reaches the end of its service life in various applications. The FPI carbon tool is used to estimate the biogenic carbon balance at year 100, including service life estimations for various applications and the average landfill decay rate. The carbon tool gives the following results:

Carbon sequestered in product at manufacturing gate:
977.57 kg CO_2 eq. = - 977.57 kg CO_2 eq emission

Methane emitted from fugitive landfill gas:
3.69 kg CH_4 = 99.00 kg CO_2 eq emission

Carbon dioxide emitted from fugitive landfill gas and the combustion of waste and captureed landfill gas:
284.57 kg CO_2 eq emission

Carbon sequestration at year 100, net of biogenic carbon emissions:
594.07 kg CO_2 eq emission = - 594.07 kg CO_2 eq emission

Additional Information

Athena: 2012. A cradle to gate life cycle assessment of Canadian oriented strand board: An Update. Athena Sustainable Materials Institute.

CORRIM:2015. Cradle to Gate Life Cycle Assessment of North American Laminated Strand Lumber Production

FPInnovations. 2015. Product Category Rules (PCR) for preparing and environmental Product Declaration (EPD) for North American Structural and Architectural Wood Products. https://fpinnovations.ca/ResearchProgram/environment-sustainability/epd-program/Documents/pcr-v2.pdf.

FPInnovations and Athena Institute: 2013. Business-to-Business Carbon Sequestration Tool https://fpinnovations.ca/ResearchProgram/environment-sustainability/epd-program/Documents/carbon-tool-user-guide-2.18.pdf

ISO 14040:2006. Environmental management - Life cycle assessment–Principles and Guidelines

ISO 14044:2006. Environmental management - Life cycle assessment–Requirements and guidelines

ISO 21930:2007. Building and Construction Assets – Sustainability in building construction – Environmental declaration of building products.

TRACI 2.0 - Tool for the reduction and assessment of chemical and other environmental impacts. http://www.epa.gov/ord/NRMRL/std/traci/traci.html

USLCI Database: https://www.lcacommons.gov/nrel/search