Environmental Product Declaration

North American Glued Laminated Timbers

AMERICAN WOOD COUNCIL
CANADIAN WOOD COUNCIL

APA - The Engineered Wood Association

The American Wood Council (AWC) and Canadian Wood Council (CWC) are pleased to present this Environmental Product Declaration (EPD) for North American glued laminated timbers (glulam). This EPD was developed in compliance with ISO 14025 and ISO 21930 and has been verified under UL Environment's EPD program.

The EPD includes Life Cycle Assessment (LCA) results for all processes up to the point that glulam is packaged and ready for shipment at the manufacturing gate; the cradle-to-gate product system includes forest management, logging, transportation of logs to lumber mills, sawing, kiln-drying, transportation of lumber to glulam plants, finger jointing and planing, gluing, and final planing.

The AWC and CWC represent wood product manufacturers across North America. Our organizations have undertaken numerous sustainability initiatives on behalf of our membership and we are pleased to present this document to show how we are doing. The publication of this EPD, which is based on rigorous LCA research, is our effort to back up with science what we know to be true – that wood products stand alone as a green building material.

Please follow our sustainability initiatives at:
www.awc.org and **www.cwc.ca**

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

AMERICAN WOOD COUNCIL
Canadian Wood Council
Conseil canadien du bois

North American Glued Laminated Timbers (Glulam)
North American Structural and Architectural Wood Products

According to ISO 14025 and ISO 21930

This declaration is an environmental product declaration in accordance with ISO 14025 that describes environmental characteristics of the described product and provides transparency and disclosure of the impacts caused by the product life cycle. This EPD does not guarantee that any performance benchmarks, including environmental performance benchmarks, are met. EPDs are intended to compliment Type I environmental performance labels.

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	American Wood Council and Canadian Wood Council
DECLARATION NUMBER	13CA24184.104.1
DECLARED PRODUCT	North American Glued Laminated Timbers
REFERENCE PCR	FPInnovations: 2011. Product Category Rules (PCR) for preparing an Environmental Product Declaration for North American Structural and Architectural Wood Products, Version 1 (UN CPC 31, NAICS 321), November 8, 2011.

DATE OF ISSUE	April 16, 2013
PERIOD OF VALIDITY	5 years
EXTENSION PERIOD	1 Year (April 16, 2019)
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:	FPInnovation PCR confirmed by PCR Review Panel 570 Saint-Jean Blvd. Pointe-Claire, QC Canada H9R 3J9 T 514 630-4100 info@fpinnovations.ca
This declaration was independently verified by Underwriters Laboratories in accordance with ISO 14025 ☐ INTERNAL ☒ EXTERNAL	Loretta Tam, EPD Program Manager
This life cycle assessment was independently verified by in accordance with ISO 14044 and the reference PCR	Thomas P. Gloria, Ph. D., Industrial Ecology Consultants

Description of Industry and Product

Description of North American Glulam Industry

The North American forest product industry is a major contributor to both the American and Canadian economies. Many glulam manufacturing jobs are rurally located and are the primary driver of local economies. In 2012, North American glulam manufacturers produced more than 213 million board feet (339 cubic meters) of glulam in 38 different facilities.

The North American glulam industry has weathered unprecedented economic changes in recent years through innovation and expansion into new and emerging markets. Efficiency improvements, beyond simply ensuring competitiveness, continually improve the environmental footprint of wood products. Now, more than ever, we are ready to present this EPD that reflects years of research and demonstrates the hard work we've been doing.

Description of Glulam Product

The product profile presented in this EPD is for a declared unit of 1 cubic meter of glulam. Glulam is manufactured by first finger-jointing dimension lumber to the desired product length and then planing and face bonding the lumber elements into a beam with pressure and one of a number of different resin types. The pressed and cured glulam products, which include beams, columns, and arches, are then planed again and packaged for shipment .

One cubic meter of average North American glulam weighs 533.97 kg, excluding the variable moisture content. The product composition is presented below and represents the weighted average of the various resin types that are used by different manufacturers:

- Wood: 525.97 oven dry kg (98.50%)
- Phenol resorcinol formaldehyde resin: 6.69 kg (1.25%)
- Melamine urea formaldehyde resin: 0.79 kg (0.15%)
- Polyurethane resin: 0.35 kg (0.07%)
- Resorcinol formaldehyde resin: 0.12 kg (0.02%)
- Melamine formaldehyde resin: 0.05 kg (0.01%)

This EPD is based on LCA studies that considered the entire range of glulam product sizes and functions. The results are presented for the metric unit of measure, 1 cubic meter, which is equal to 630 board feet (0.63 mbfm).

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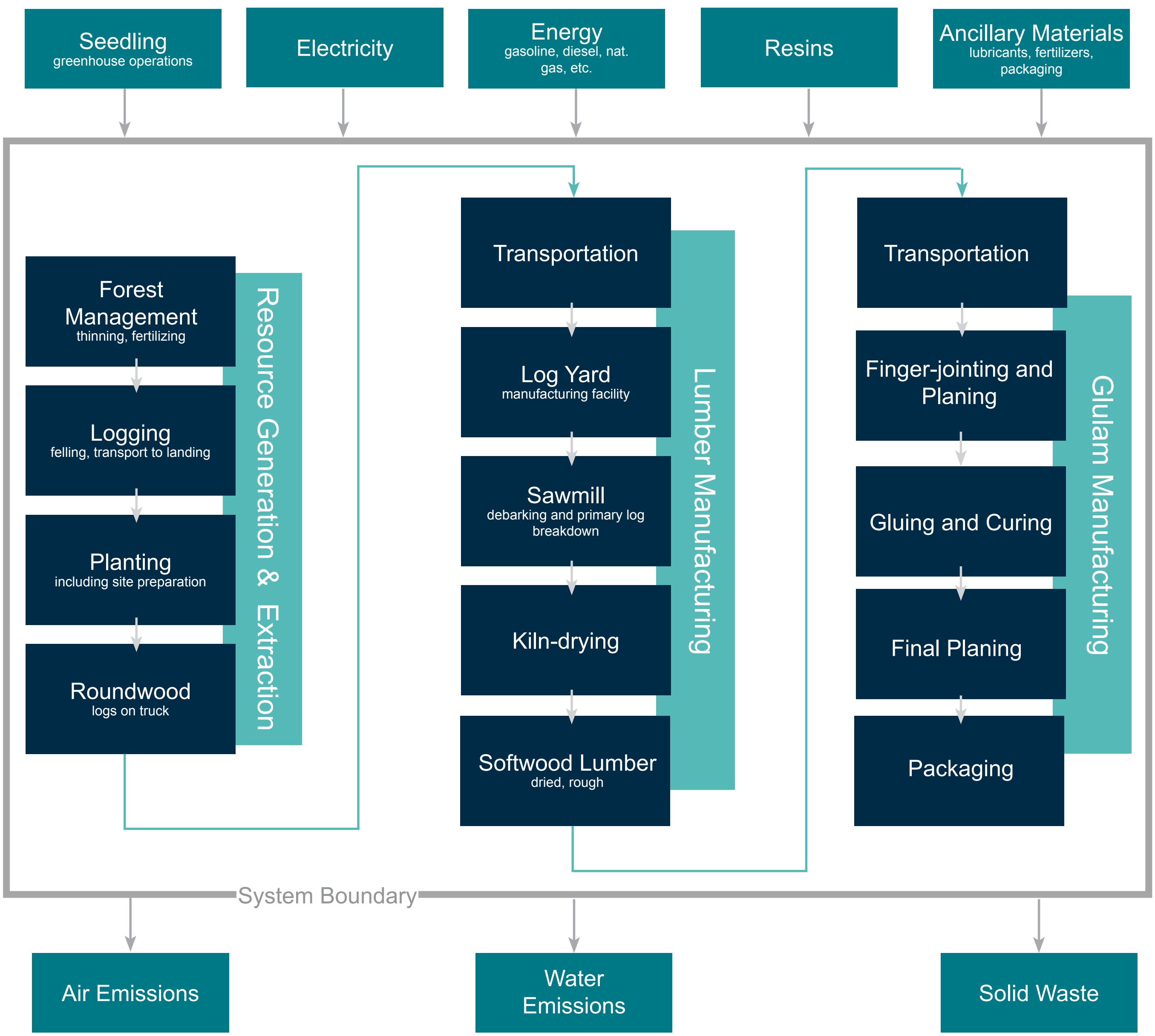
Cradle-to-Gate Life Cycle of Glulam

Figure 1: Cradle-to-gate product system for Glulam



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

Business-to-business EPD's are those that focus on the life cycle up to the point that the product has been manufactured and is ready for shipment, the portion of the life cycle referred to as cradle-to-gate. This EPD includes the cradle-to-gate processes as shown in Figure 1 on the previous page.

The delivery of the product to the customer, its use, and eventual end-of-life processing are excluded from the cradle-to-gate portion of the life cycle. This exclusion limits the accounting of carbon sequestration in the wood product because the benefit of sequestration is not realized at the point of manufacturing, but occurs over the life cycle of the product.

Forest Operations

The assessment of the life cycle impacts of a wood product begins with its origin in natural or managed forests and the energy use and emissions caused by its extraction. Forest management and the reforestation that occurs after extraction are also included. The PCR requires that the cradle-to-gate product system includes all forest management activities which may include site preparation, thinning, and fertilization. The forest operations portion of the resource extraction/generation phase also includes the production and planting of seedlings that occurs after logging.

Glulam Production

The glulam production phase begins with the transportation of logs to the upstream sawmills, where they are sawed, and kiln-dried. The lumber is then transported to glulam manufacturing facilities where it is finger jointed, planed, glued under pressure and then planed again. These processes consume electricity drawn from regional grids, fossil fuel, and internally generated biomass.

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Methodology of Underlying LCA

Declared Unit

The declared unit in this EPD is 1 cubic meter (m^3) of glulam. This is equivalent to 630 board feet (0.63 mbfm). The average density of North American glulam including resins and excluding moisture content is 533.97 oven dry kg/m^3. Glulam produced in North America is understood to have some moisture in the product, while the oven dry unit of measure contains neither free moisture (moisture in cell cavities) nor bound moisture (moisture in cell walls).

System Boundaries

The system boundary begins with the forest management and resource extraction and ends with finished glulam ready for shipment at the manufacturer. The forest resources system boundary includes planting the seedlings, site preparation, thinning, fertilization and final harvest. Glulam manufacturing includes the transportation of logs to upstream sawmills, sawing, kiln-drying, transportation of lumber to glulam manufacturers, finger-jointing and planing, gluing, curing, and final planing. Seedlings and the fertilizer and electricity it took to grow them were also considered in the system boundary.

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 system model 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, based on a sensitivity analysis, it is included within the system boundary.

Data Quality

Precision and Completeness

Primary data on raw materials, energy, and emissions were provided by logging operations, lumber mills, and glulam manufacturing facilities, based on input purchases, production output, and reported process emissions. All upstream and downstream secondary data was drawn from publicly available databases, primarily the United States Life Cycle Inventory (USLCI) database. The LCA practitioners performed quality control on all secondary data sources to ensure completeness.

All inventory flows were modeled and at no time were data excluded due to application of the studies' cut-off criteria.

Consistency and Reproducibility

To ensure consistency, only primary data as provided by the study participants were used to model gate-to-gate glulam 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 LCA reports.

Temporal Coverage

Primary data collected from the manufacturing facilities related to the product processes of interest are representative for the years 2004-2009. The LCA models were updated in 2012 to reflect updates in underlying secondary data used to develop the LCI.

Geographical Coverage

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

Treatment of Biogenic Carbon

Biogenic carbon dioxide emissions were accounted 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 dependant 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

Allocation followed the requirements and guidance of ISO 14044:2006, clause 4.3.4, which gives preference to mass based allocation, and the following description of allocation from the PCR:

- Allocation of multi-output processes shall be based on mass. However, if economic value difference is at least ten times greater between products from a multi-output process, a suitable revenue based allocation principle shall be applied and these deviations shall be substantiated and readily available for review.

The glulam co-products fall within this 10 times value threshold and were thus allocated on a mass basis.

Aggregation of Regional Results

The LCA results that follow represent the weighted average of three different LCA studies; one for each of the two primary American manufacturing regions and one Canadian average study. The three regions and their weighting relative to the aggregate profile are as follows:

- United States - Pacific Northwest: 34%

- United States - Southeast: 60%

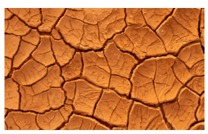
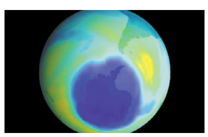
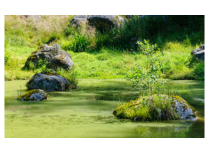
- Canada - National Average: 6%

The weighting factors were developed from the relative annual production of the three manufacturing regions. The United States regional weights are based on the production totals for the years 2001-2009 which is representative of the data vintage that underlies those two studies. The Canadian weight is based on the 2010 production year to represent the more recent data that was used in that study. The selection of 2010 for the Canadian weighting is also conservative because North American glulam production was lower in that year than in the preceding years. This means that the potential Canadian impacts, which are generally lower than those of the American regions, is weighted less than if the same production years were selected for all weight derivations.

In addition to calculating weighted average impact assessment results, these weighting factors were also used to calculate the weighted average density of North American glulam. All other values presented in this EPD also utilize this weighting.

Life Cycle Assessment Results

The life cycle impact assessment (LCIA) establishes links between the life cycle inventory results and 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 the table below. Environmental impacts are determined using the TRACI 2 method. These five impact categories are reported consistently with the requirements of the PCR.

Table 1: 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 kg 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 H^+ moles 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 Results

The impact assessment results are shown in Table 2. 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. Additionally, each impact indicator value is stated in units that are not comparable to others.
Some variations exist between the three underlying data sets and are a result of differences in regional energy mixes, particularly the sources of electricity, as well as differences in production practices and efficiencies.

The results presented below indicate the potential impacts caused by the cradle-to-gate production of glulam. Ozone depletion was below 10^{-5} kg CFC-11 eq. in all three of the LCA studies and is thus not reported in the results table. Water consumption was estimated for Canada as required by the PCR. However, the U.S. regional estimate include all water withdrawals without netting out non-consumptive use. As a result, the combined weighted average overstates total water consumption and is therefore conservative.

Table 2: Cradle-to-Gate Impact Assessment Results - 1m^3 North American Glulam

Impact category indicator	**Unit**	**Total**	**Forestry operations**	**Glulam production**
Global warming potential	kg CO_2 eq.	197.97	11.37	186.59
Acidification potential	H+ moles eq.	102.67	8.33	67.55
Eutrophication potential	kg N eq.	0.1198	0.0228	0.0970
Ozone depletion potential	kg CFC-11 eq.	0.0000	0.0000	0.0000
Smog potential	kg O_3 eq.	26.12	4.27	21.86
Total primary energy consumption	**Unit**	**Total**	**Forestry operations**	**Glulam production**
Non-renewable fossil	MJ	3211.72	173.32	3038.40
Non-renewable nuclear	MJ	338.86	1.71	337.15
Renewable, biomass	MJ	2201.18	0.00	2201.18
Renewable, other	MJ	82.40	0.22	83.16
Material resources consumption	**Unit**	**Total**	**Forestry operations**	**Glulam production**
Non-renewable materials	kg	4.10	0.00	4.10
Renewable materials	kg	553.80	30.44	523.37
Fresh water	L	963.21	4.42	958.79
Non-hazardous waste generated	**Unit**	**Total**	**Forestry operations**	**Glulam production**
Solid waste	kg	36.83	0.17	36.67

Impact Assessment Results by Life Stage

The two graphs below show that glulam manufacturing itself is the primary driver of impacts in the cumulative cradle-to-gate product system. Glulam manufacturing consumes 95% of fossil fuels and 100% of biomass energy, which drive the impacts in every category.

Figure 2: Cradle-to-Gate Impact Assessment Results

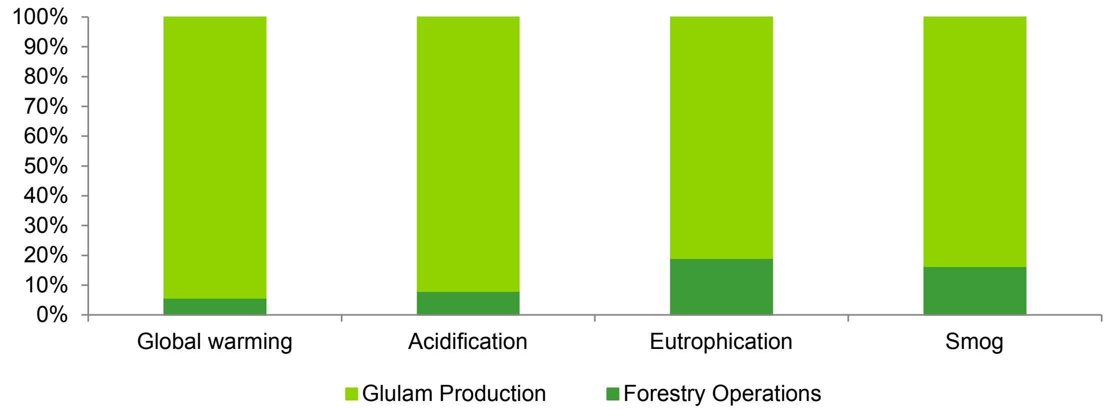


Figure 3: Cradle-to-Gate Primary Energy Consumption

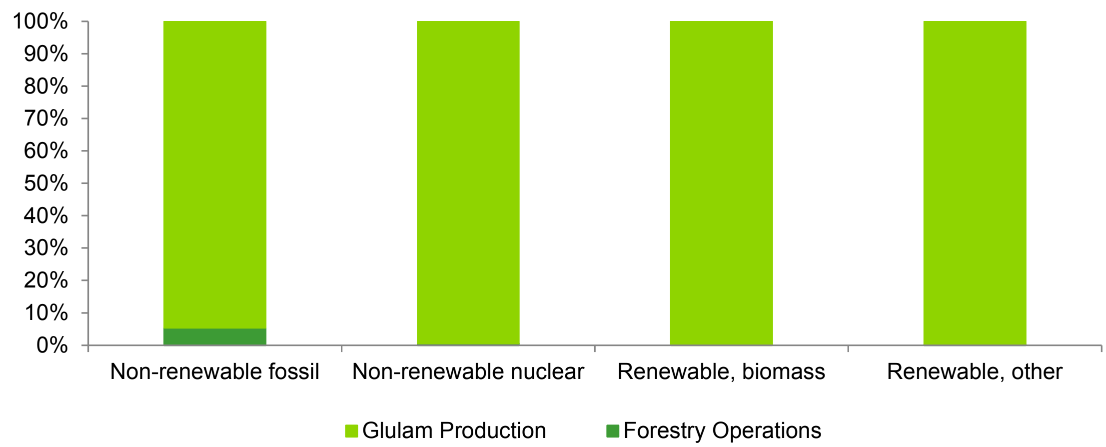


Figure 4: Cradle-to-Gate Energy Use

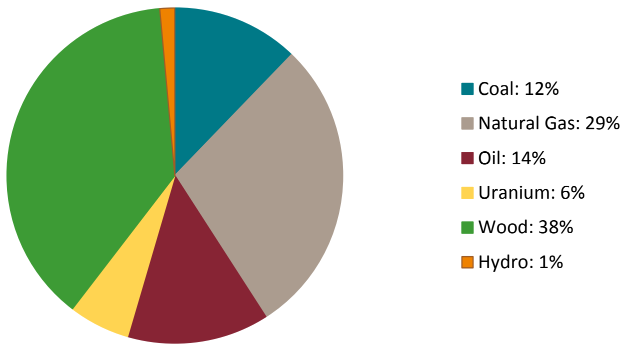


Figure 5: Forestry Operations Energy Use

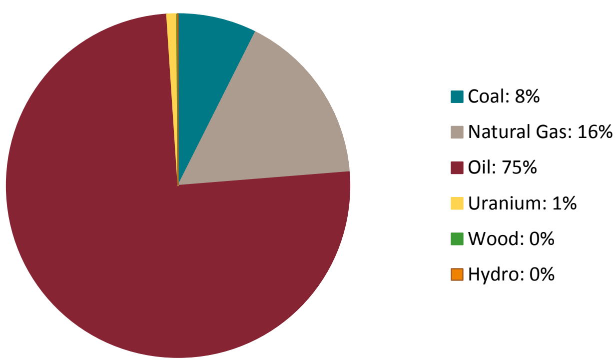
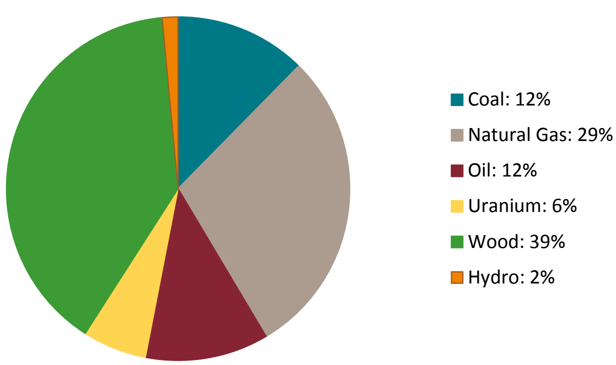


Figure 6: Glulam Production Energy Use



Primary Energy Consumption by Resource

The three pie charts show the consumption of various energy resources in the cradle-to-gate portion of the life cycle. The cradle-to-gate and glulam production charts show similar results as manufacturing consumes the bulk of cradle-to-gate energy.

The forest operations portion of the life cycle relies heavily on oil-based energy as consumed in the form of diesel by heavy machinery. Oil accounts for 75% of energy resources consumed in forestry operations.

A significant portion of the energy requirement in manufacturing is met by renewable energy sources, 39% from biomass and 1% from hydro power. This translates to 38% of cradle-to-gate energy use for biomass and 1% for hydro power. The biomass consumption is used exclusively in the upstream kiln-drying process in lumber manufacturing while the hydro energy use is due to electricity that is consumed throughout the cradle-to-gate product system. Coal, natural gas, oil, and nuclear comprise the remaining energy use.

The prevalence of renewable energy use in the life cycle of glulam means that 55% of energy consumption is derived from fossil fuel sources. This means that glulam has a particularly low carbon footprint relative to the energy required for glulam manufacturing.

Additional Information

Range of Applications

Glulam is used exclusively in residential and non-residential construction. Glulam is somewhat unique amongst wood products in that it is most commonly used in non-residential commercial construction.

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

- New non-residential construction: 56%
- New single family residential construction: 33%
- New multifamily residential construction: 7%
- Residential upkeep and improvement: 3%
- Mobile home construction: 1%

Source: APA - Engineered Wood Association (2012) Structural Panel and Engineered Wood Yearbook, APA Economics Report E178.

Photos: APA - The Engineered Wood Association

Carbon Sequestration

The 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 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 sequestered 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 carbon tool):

1m^3 glulam = 525.97 oven dry kg = 262.98 kg Carbon = 964.28 kg CO_2 eq.

This initial carbon sequestration may then be considered against its emission as the glulam 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:
964.28 kg CO_2 eq. = - 964.28 kg CO_2 eq emission

Methane emitted from fugitive landfill gas:
2.75 kg CH_4 = 68.82 kg CO_2 eq. emission

Carbon dioxide emitted from fugitive landfill gas and the combustion of waste and captured landfill gas:
212.91 kg CO_2 eq. emission

Carbon sequestration at year 100, net of biogenic carbon emissions:
682.55 kg CO_2 eq. = - 682.55 kg CO_2 eq. emission

References

APA - Engineered Wood Association (2012) Structural Panel and Engineered Wood Yearbook, APA Economics Report E178.

Athena Institute: 2012. A Cradle-to-Gate Life Cycle Assessment of Canadian Glulam

CORRIM:2012. Cradle to Gate Life Cycle Assessment of Glue-Laminated Timber Production from the Pacific Northwest

CORRIM:2012. Cradle to Gate Life Cycle Assessment of Glue-Laminated Timber Production from the Southeast

FPInnovations: 2011. Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for North American Structural and Architectural Wood Products, Version 1 (UN CPC 31, NAICS 321), November 8, 2011. http://www.forintek.ca/public/pdf/Public_Information/EPD%20Program/PCR%20November%208%20 2011%20Final.pdf

FPInnovations and Athena Institute: 2013. Business-to-Business (B2B) Carbon Sequestration Tool for Wood EPD's as per PCR for North American Structural and Architectural Wood Products, Version 1.

ISO 14040:2006. Environmental Management – Life Cycle Assessment – Principles and Framework.

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: Tool for the Reduction and Assessment of Chemical and other environmental Impacts: http://www.epa.gov/ORD/NRMRL/std/sab/traci/

USLCI Database: http://www.nrel.gov/lci