Environmental Product Declaration

Medium Density Fiberboard

COMPOSITE PANEL ASSOCIATION

Medium Density Fiberboard (MDF) is a composite panel product used for composite furniture, kitchen cabinets, molding, and laminate floors.

Composite Panel Association

The Composite Panel Association is pleased to present this Environmental Product Declaration (EPD) for Medium Density Fiberboard (MDF). 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 MDF is packaged and ready for shipment at the manufacturing gate. The life cycle of MDF includes the production of wood residues that are a coproduct of lumber milling. The cradle-to-gate product system thus includes forest management, logging, transportation of logs to lumber mills, sawing, transportation of wood residues to MDF plants, and MDF production.

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www.compositepanel.org/cpa-green/

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

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	Composite Panel Association
DECLARATION NUMBER	4788663642.101.1
DECLARED PRODUCT	North American Medium Density Fiberboard
REFERENCE PCR	FPInnovations PCR for North American Structural and Architectural Wood Products, v.2.0 2015
REFERENCE PCR STANDARD	☐ EN 15804 (2012) ☒ ISO 21930 (2007) ☐ ISO 21930 (2017)
DATE OF ISSUE	December 31, 2018
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:	FPInnovations PCR Peer Review Panel Chair: Thomas P. Gloria,
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Grant R. Martin Grant R. Martin, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	James Mellentine James Mellentine, Ramboll

Description of Industry and Product

Description of North American MDF Industry

The North American composite panel industry is a major contributor to both the United States and Canada economies. MDF is a composite panel that is valued for its homogeneity that allows precision millwork and finishing. These properties have caused MDF to be widely used to manufacture furniture, kitchen cabinets, doors, and moulding. MDF is also widely regarded as a sustainable material because it utilizes wood residues from other manufacturing processes that might otherwise be wasted. In 2016, total North American production of MDF was over four million m^3, with three million m^3 from United States facilities and Canada producing an additional one million m^3.

Manufacturers of MDF in North American are members of the Composite Panel Association, Leesburg, Virginia. Nine MDF facilities contributed production data from the United States and Canada (Table 1) for this EPD with a combined production of 1.8 million m^3, or 45% of total industry production.

Table 1: Participating Facilities

Manufacturer	City, State/Province	Country
Arauco North America	Eugene, Oregon	United States
Arauco North America	Malvern, Alaska	United States
Arauco North America	Moncure, North Carolina	United States
Arauco North America	Sault Ste. Marie, Ontario	Canada
Arauco North America	St. Stephen, New Brunswick	Canada
Uniboard Inc.	Mont-Laurier, Quebec	Canada
West Fraser/ Ranger Board	Blue Ridge, Alberta	Canada
West Fraser/WestPine	Quesnel, British Columbia	Canada
Weyerhaeuser NR	Columbia Falls, Montana	United States

Description of MDF Product

The product profile presented in this EPD is for a declared unit of 1 cubic meter of MDF. MDF is manufactured from wood residues that are generated as a coproduct of lumber milling. The cradle-to-gate product system thus includes forest management, logging, transportation of logs to lumber mills, sawing, transportation of wood residues to MDF plants, MDF production, and packaging for shipment .

One cubic meter of average North American MDF weighs 782.41 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 residues: 702.31 oven dry kg (89.77%)
- Urea formaldehyde (UF) resin: 58.13 kg (7.43%)
- Melamine urea formaldehyde (MUF) resin: 8.59 kg (1.10%)
- Urea: 5.46 kg (0.70%)
- Polymeric diphenyl methane diisocyanate (PMDI) Resin: 2.88 kg (0.37%)
- Ammonium Sulfate: 0.10 kg (0.01%)
- Ammonium Chloride: 0.18 kg (0.02%)
- Slack wax: 4.75 kg (0.61%)

This EPD is based on LCA studies that considered the entire range of MDF product sizes and functions. The results are presented for the metric unit of measure, 1 cubic meter, which is equal to 565 square feet (3/4” thickness).

Business-to-Business Industry Average EPDs

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 and in more detail in Figure 2.

Type III environmental product declarations intended for business-toconsumer communication shall be available to the consumer at the point of purchase. This Type III environmental declaration is developed according to ISO 21930 and 14025 for particleboard. 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. EPDs do not report product environmental performance against any benchmark.

EPDs from different programs may not be comparable. This EPD represents an average performance, in such cases where an EPD declares an average performance for a number of products (i.e., a weighted average based on volume of production that represents the technology, process and energy sources used).

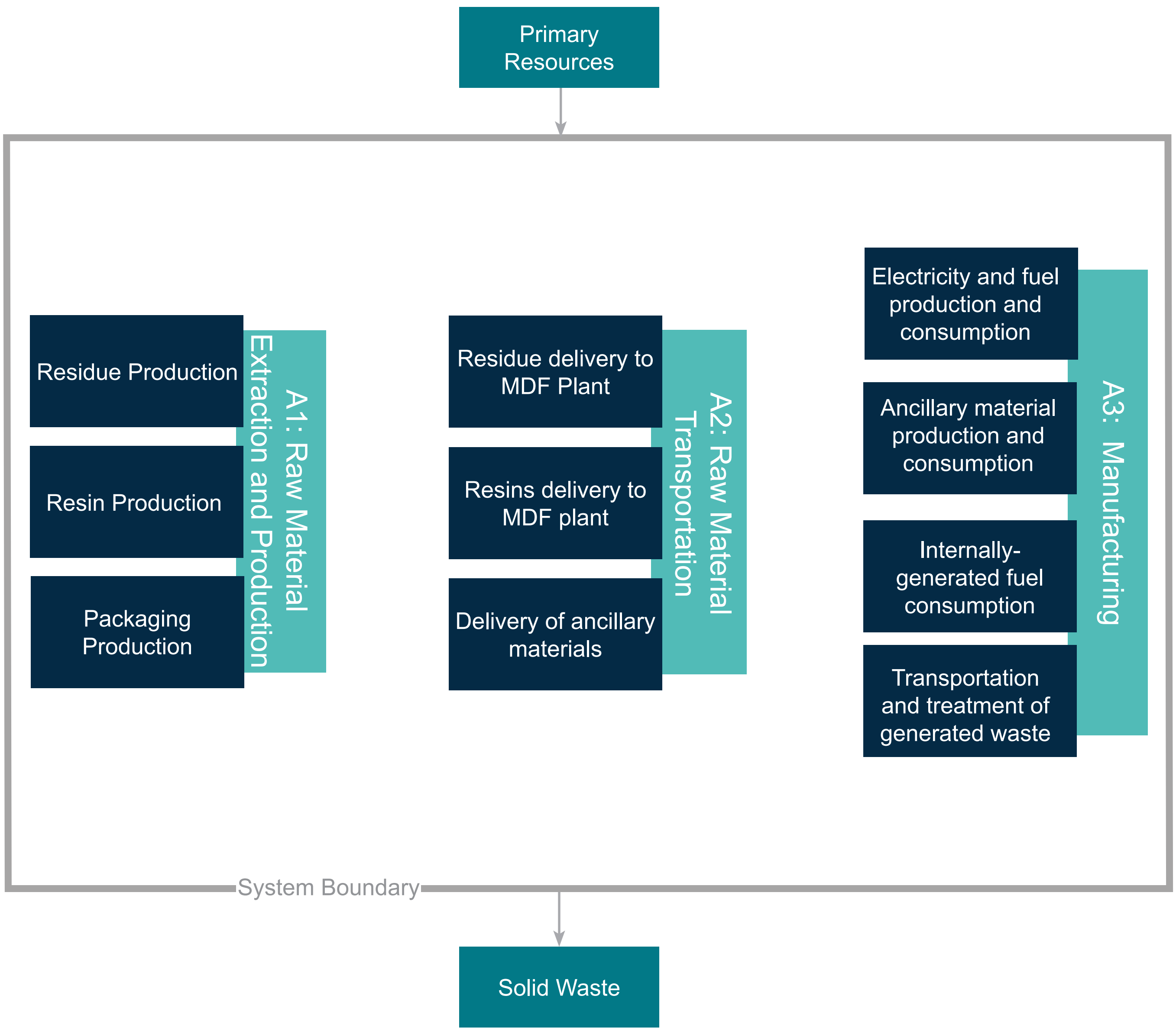
Figure 1: Description of the System Boundary

Description of the System Boundary (x : included in LCA; mnd: module not declared)

Product			Construction Installation		Use							End-of-life				Benefits Beyond the System		
Raw Material supply	Transport	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D
x	x	x	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd

Cradle-to-Gate Life Cycle of MDF

Figure 2: Cradle-to-gate product system for MDF



Methodology of Underlying LCA

Declared Unit

The declared unit in this EPD is 1 cubic meter (m^3) of MDF. This is equivalent to 565 square feet (3/4" thickness). The average density of North American MDF including resins and excluding moisture content is 782.41 oven dry kg/m^3. MDF 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 regeneration in the forest and ends with the MDF product (Figure 1 and Figure 2). The system boundary includes forest operations (A1), which may include site preparation and planting seedlings, fertilization and thinning, final harvest, residue production, and resin production. Transportation of all resources and materials (A2) to the MDF facility and MDF production (A3) are also included in the product system. The MDF production complex was modeled as a single unit process. The study recognized twelve steps (A3) necessary to make MDF. Excluded from the system boundaries are fixed capital equipment and facilities, transportation of employees, land use, delivery of MDF to construction site, construction, maintenance, use, and final disposal.

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

Three cradle-to-gate life cycle stages (A1: Raw material extraction and production, A2: Transportation, and A3: MDF manufacturing) were checked for data completeness including all input elements such as raw and ancillary materials input, energy input, transportation scenarios, water consumption, and outputs such as products and coproducts, emissions to air, water, land, and final waste disposals. All input and output data were found to be complete and no significant data gaps were identified.

Consistency and Reproducibility

To ensure consistency, only primary data provided by the mill participants were used to model gate-to-gate processes (A3). All other secondary upstream data were consistently applied across MDF system boundary. At various points in the study (data collection and modeling) a quality and consistency check were performed. The quality check process included a review of the precision and completeness of the collected primary data (e.g. mass and energy balance were performed), applicability of LCI datasets used, general model structure, and results plausibility. The data was found to be within acceptable ranges compared to internally and publicly available information.

Temporal Coverage

Primary data collected from the manufacturing facilities for their operational activities related to the product processes of interest are representative for the year 2016 (reference year). Additional data necessary to model base material production and energy use, etc. was adapted from various secondary databases (CORRIM datasets, USLCI-TS, and ecoinvent)

Geographical Coverage

The geographical coverage for this study is based on United States and Canada system boundaries for all processes and products. Whenever North American background data was not readily available, European data (adjusted for North American system boundaries) was used as a proxy.

Allocation

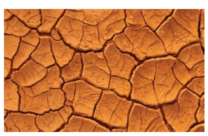
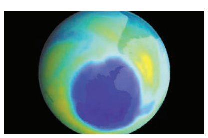
Allocation is the method used to partition the environmental load of a process when several products or functions share the same process. MDF is the only valuable output from the manufacturing facility and thus no allocation was applied to A3-product manufacturing.

The wood fiber raw material input is a product of multiple output processes, namely the milling of lumber in the different source regions. In these cases, mass allocation data for fibers was conservatively chosen. Wood fibers are a lower value coproduct than the primary product, lumber, and thus the impacts are higher for fibers in a mass allocation profile. Further, mass allocation data was available for all of the regions participating in this study.

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 Table 2 below. Environmental impacts are determined using the TRACI 2.1 method. These five impact categories are reported consistently with the requirements of the PCR.

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 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 kg SO_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 Results

The impact assessment results are shown in Table 3 on the following page. 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 variation exists between the two underlying data sets and is 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 in Table 3 on the following page indicate the potential impacts caused by the cradle-to-gate production of MDF. The LCA includes all water withdrawals without netting out non-consumptive use. As a result, the weighted average overstates total water consumption and is therefore conservative.

Table 3: Cradle-to-Gate Impact Assessment Results - 1m³ North American MDF

Impact category indicator	Unit	Total	A1	A2	A3
Global warming potential	kg CO_2 eq.	759.15	319.69	9.44	430.02
Acidification potential	kg SO_2 eq.	5.52	2.66	0.11	2.74
Eutrophication potential	kg N eq.	3.42	0.54	0.01	2.87
Ozone depletion potential	kg CFC-11 eq.	5.81E-05	3.76E-05	4.00E-10	2.04E-05
Smog potential	kg O_3 eq.	69.63	33.22	2.80	33.61
Total primary energy consumption	**Unit**	**Total**	**A1**	**A2**	**A3**
Total primary energy	MJ	17,546.73	7,696.97	134.81	9,714.95
Non-renewable fossil	MJ	10,578.48	5,249.66	133.58	5,195.24
Non-renewable nuclear	MJ	1,370.91	170.83	1.23	1,198.85
Renewable, biomass	MJ	5,046.25	2,173.94	0.00	2,872.31
Renewable, other	MJ	551.10	102.54	0.00	448.56
Material resources consumption	**Unit**	**Total**	**A1**	**A2**	**A3**
Non-renewable materials	kg	49.45	33.82	0.00	15.63
Renewable materials	kg	1,049.94	1,031.79	0.01	18.15
Fresh water	L	3,017.45	1,241.23	0.00	1,776.22
Waste generation	**Unit**	**Total**	**A1**	**A2**	**A3**
Hazardous waste generated	kg	0.00	0.00	0.00	0.00
Non-hazardous waste generated	kg	12.36	0.00	0.00	12.36

Impact Assessment Results by Life Stage

The two graphs below show that particleboard manufacturing itself is the primary driver of impacts in the cumulative cradle-to-gate product system. Figure 2 shows that particleboard manufacturing, A3, consumes 54% of non-renewable fuels which drive the impacts in every category. Figure 3 shows the breakdown of impacts caused by the upstream production of raw material inputs and the fact that resin production accounts for 59% of non-renewable energy use that drives impacts in every category.

Figure 2: Cradle-to-Gate Impact Assessment Results

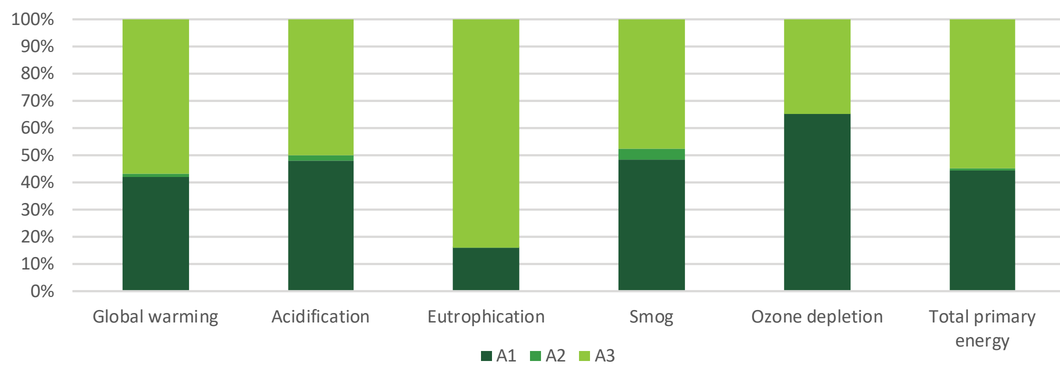


Figure 3: A1 - Raw Materials Production Contribution Analysis

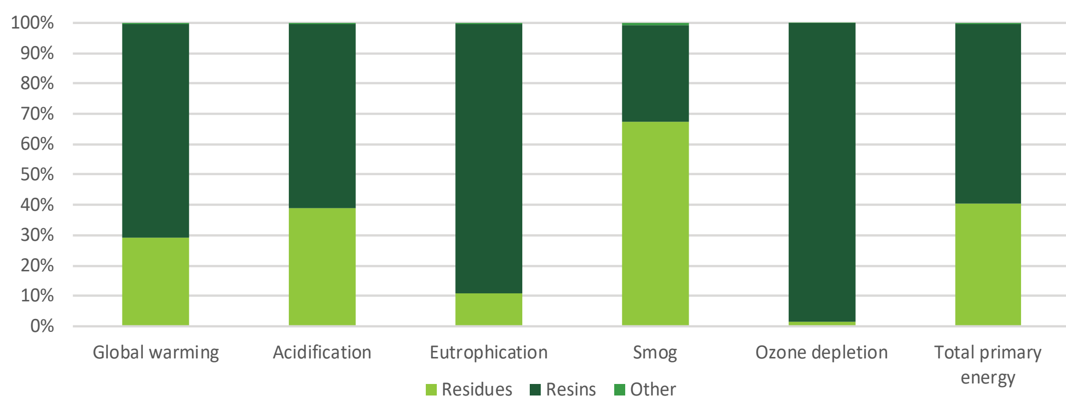


Figure 4: Cradle-to-Gate Energy Use

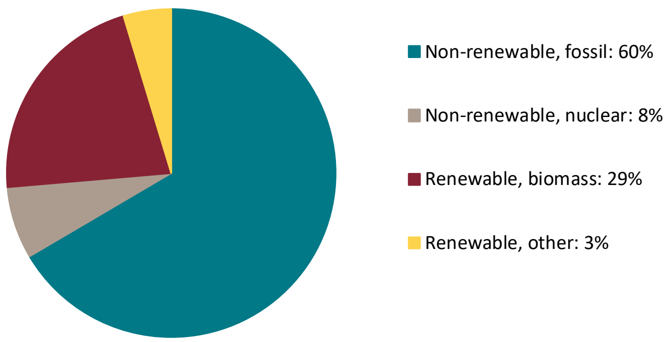


Figure 5: A1 - Raw Materials Production Energy Use

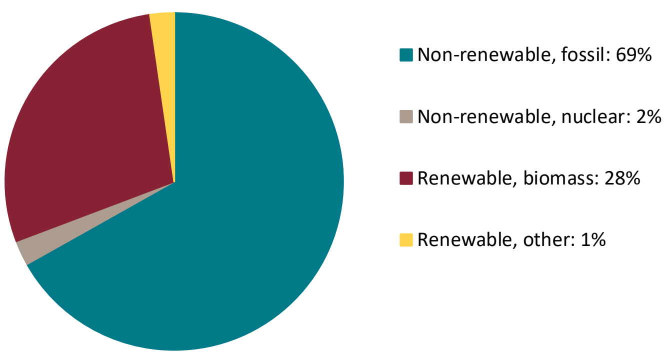
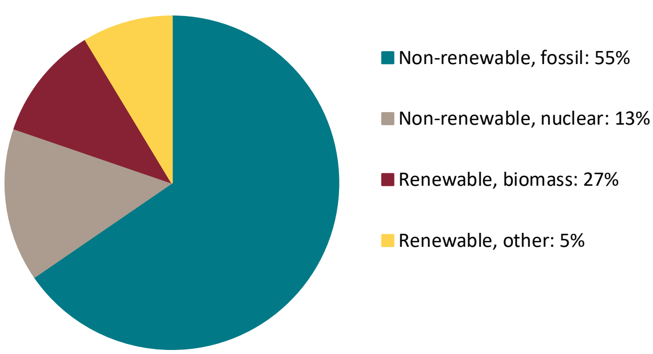


Figure 6: A3 - Manufacturing Energy Use



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 MDF production charts show similar results as manufacturing consumes the bulk of cradle-to-gate energy.

The cradle-to-gate life cycle relies heavily on oil-based energy as consumed in the form of diesel by heavy machinery used in logging, and transportation of materials as well as natural gas used to heat the production facilities. Non-renewable energy accounts for 60% of energy resources consumed in the cradle-to-gate life cycle.

A significant portion of the energy requirement in manufacturing is met by renewable energy sources, 27% from biomass and 5% from hydro power. This translates to 29% of cradle-to-gate energy use for renewable sources. Biomass is also used in the upstream residue production as a readily available coproduct of lumber milling. Besides biomass and hydroelectricity, coal, natural gas, oil, and nuclear power comprise the remaining energy use.

The prevalence of renewable energy use in the life cycle of MDF means that MDF has a particularly low carbon footprint relative to the energy required for manufacturing.

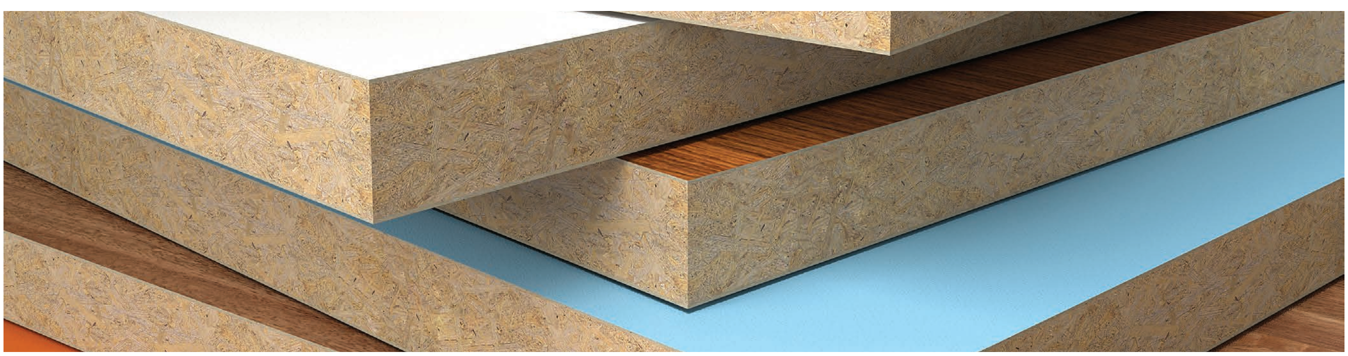
Additional Information

Range of Applications

Medium Density Fiberboard (MDF) is a composite panel product used for non-structural applications such as composite furniture, kitchen cabinets, molding, and laminate floors. The breakdown of uses for MDF is as follows:

- Millwork and moulding: 22%
- Flooring: 18%
- Residential and office furniture: 12%
- Cabinets, vanities, and countertops: 11%
- Other uses: 37%

Source: 2016 North American Shipments and Downstream Market Report. Summarizing shipment data of particlboard, medium density fiberboard, hardboard and engineered wood siding and trim. 2016. Composite Panel 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 (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 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 MDF = 705.17 oven dry kg = 352.59 kg Carbon = 1292.82 kg CO_2 eq.

This initial carbon sequestration may then be considered against its emission as the MDF 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:
1292.82 kg CO_2 eq. = - 1292.82 kg CO_2 eq emission

Methane emitted from fugitive landfill gas:
9.58 kg CH_4 = 239.44 kg CO_2 eq. emission

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

Carbon sequestration at year 100, net of biogenic carbon emissions:
494.32 kg CO_2 eq. = - 494.32 kg CO_2 eq. emission

References

Composite Panel Association (CPA). 2017. 2016 North American Shipments Report – Particleboard, Medium Density Fiberboard, and Hardboard. 32pp.

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