CORRIM: Phase I Final Report

Module F

COMPOSITE I-JOISTS

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EXECUTIVE SUMMARY

The objectives of this study were to develop a life cycle inventory (LCI), carbon flow, and cost analysis for the production of composite I-joists, or I-joists, based on current manufacturing practices in the Pacific Northwest (Oregon, Washington) and the Southeast (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, and Texas). Composite I-joists are structural building products that are used in floor and roof systems as replacements for structural lumber in residential and light commercial applications. I-joists are most commonly made from laminated veneer lumber (LVL) and oriented strand board (OSB), however, in certain instances structural lumber and plywood components are used. As the name implies, I-joists are "I" shaped in cross-sectional profile with flanges on top and bottom with a panel product serving as the connecting web. In the PNW, the most common input products are LVL as the flange material and OSB as the web. The LVL is manufactured in the PNW from Douglas fir veneers while the OSB must be shipped either from other regions in the US or from Canada. In the SE, LVL and OSB are also the most common inputs to manufacture I-joists. The LVL is made from a combination of pine species (loblolly, slash), which are known as southern pine. I-joist plants were surveyed in each region to record all input and output data associated with the manufacturing process for the production year 2000. In the PNW the surveyed mills represented almost 33% of the total production of I-joists for the region and in the SE represented approximately 27% of the total production in that region. Input data collected included transportation distances and the use of wood (LVL and OSB) inputs materials, electricity, fuel, and resins. Output data from the surveys contained the quantity of I-joists, the co-product of sawdust, as well as emissions to land, air, and water. The quality of the data is considered good for this type of study based on between plant comparisons, and mass and energy balances.

A black box approach was used to model the LCI of I-joist manufacturing. This was done because of the relative simplicity of the I-joist process in that has a small number of unit processes. While this type of modeling is much less involved than a unit-process approach, it is sufficient in this instance. The disadvantage of a black box approach is the inability to analyze individual unit processes which may be improved. It is still possible to look at the total number of emissions and determine on an overall production basis which inputs into the process are creating the largest amounts of emissions. Therefore, the process can still be analyzed on the whole for possible improvements. This is important considering the recent attention given to the conservation of raw materials, concerns about the impact of emissions upon the environment, as well as increases in the costs of electricity and fuel. This LCI data will serve as a useful benchmark to assess the environmental performance and economic feasibility of process improvements.

The life cycle inventory (LCI) data was done for two scenarios, 1) considering site-generated emissions, and 2) considering total emissions that included site-generated emissions as well as off-site generated emissions to produce OSB and LVL, electricity and fuels. The LCI data did not include transportation of materials and products (tables are given to provide transportation distances) and did not include the generation of logs from the forest resource.

All of the inputs and outputs were determined per thousand linear feet (MLF) of I-joists. Since I-joists have a non-rectangular shape it is meaningless to specify a volume (cubic feet) basis for measuring them. As a result, the I-joist units are only linear in dimension with no consideration for any other dimensions. This is common practice when dealing with I-joists as it is done by agencies such as the APA–The Engineered Wood Association as well as NCASI. The amount of natural gas and electricity for each plant were relatively small with the PNW using 84.1 kWh per MLF of electricity and 5,020 Btu per MLF of natural gas. In the SE the electricity use was lower at 75.1 kWh per MLF but natural gas was considerably higher at 65,000 Btu per MLF. The greater use of natural gas in the SE is due to the use of phenol-formaldehyde resin that must be heated in order to cure. The PNW and the SE had recovery rates of 89.8% and 93.0% percent respectively as determined by the output of I-joist as a percentage of the wood inputs recorded at the plants. These recovery numbers are also used to allocate emissions listing in the life cycle inventory. In the PNW the inputs to make 1.0 MLF of I-joists were 1,134 lbs of laminated veneer lumber (LVL) and 1,103 lbs of oriented strand board (OSB). In the SE, the inputs to make 1.0 MLF of I-joists were 1,607 lbs of LVL and 1,194 lbs of OSB. The difference in LVL weights in the two regions can be mainly attributed to density differences for the LVL input and the fact that the SE tended to make I-joists with larger flanges, which translates to more LVL being used.

Emissions to the land, air, and water are becoming increasingly important in terms of plant operations and manufacturing costs. In this study there are two different cases for emissions: 1) total emissions for the entire I-joist manufacturing process, including the emissions associated with the production and delivery of LVL, OSB, resins, fuel, energy, and electricity; and 2) emissions associated with the I-joist manufacturing process only. The emissions for the two cases are referred to as off-site and site generated emissions respectively. Burdens, also known as the allocation of emissions, were assigned to products and co-products on a mass basis. A co-product is any material that is created during the manufacture of a product, which is sold outside of the I-joists system. Emissions for I-joists in the PNW had a burden of 89.8% and the SE had a burden of 93%. The majority of the emissions were assigned to I-joists while the remaining percentage went to the co-product sawdust.

The data can still be used to help I-joist plants assess their operations in order to further optimize production. The LCI data could also be used as a benchmark to assess environmental improvements.

A critical external review of LCI process and analysis for I-joists was conducted to ensure compliance with CORRIM and ISO 14040 protocol. The LCI data for this product, with LCI data for log generation and the production of LVL and OSB, was used by CORRIM to develop life cycle assessments of I-joists when used as a structural material for constructing residential houses. The I-joist LCI data was also provided for inclusion in the US LCI Database.

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1.0 MANUFACTURE OF COMPOSITE I-JOISTS

1.1 INTRODUCTION

Composite I-joists, or I-joists, are relatively new wood-based building materials that are designed to replace structural lumber in floor and roof joist systems or to be competitive with steel floor and roof systems. Composite I-joists are engineered products and are comprised of two different main components. As the name implies, these products have an "I" shaped cross-section with the top and bottom flanges separated by a narrow "webbing" material. In most modern I-joists, the flanges are made from laminated veneer lumber (LVL) that has been ripped into specific dimensions, while the web material is generally made from oriented strand board (OSB). In some instances the flange material is made from solid sawn lumber and the web material can be made from plywood. There are many different dimensions of composite I-joists but the most common are dimensions that directly replace 2x10 inch and 2x12 inch structural lumber. The I-joists are usually made in continuous lengths and then cut to 60-foot lengths for shipping. Figure 1.1 shows a typical composite I-joist.

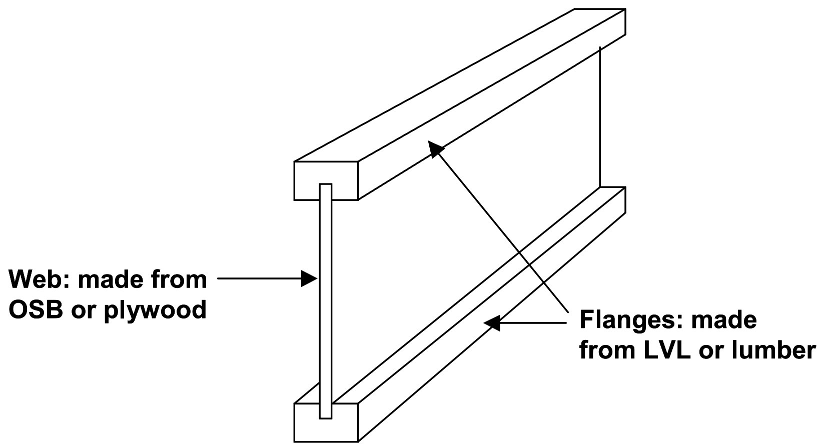

Figure 1.1. Diagram of the Cross-section of a Typical Composite I-joist.

This report is being completed for the Consortium for Research on Renewable Industrial Materials (CORRIM Inc.) with the emphasis being put on wood-based building materials used in residential and light commercial buildings. The purpose of this report is to document the life cycle inventory (LCI) of manufacturing I-joists based on resources from the Pacific Northwest (PNW) and Southeast (SE) regions. All of the inputs used to make I-joists are generated in the region that they are produced with the exception of OSB. There are no facilities in the PNW that produce OSB, therefore it must be shipped from the eastern US or northwestern Canada. This report relied heavily on inputs from LCI's for other products in the CORRIM Phase I final report, particularly laminated veneer lumber, oriented strand board, phenol-formaldehyde (PF) resin and isocyanate (MDI) resin. The OSB model was created by Earl Kline at Virginia Tech (Kline 2004) and put into a "black box" model by Jim Wilson at Oregon State University for use in this study. The LCI data for PF was from ATHENA™ and the MDI comes from a database within SimaPro that was generated by Boustead Consulting (Pre' Consultants 2001), SimaPro is the brand name of the software used to complete the I-joist LCI. The LVL model was done as a part of the I-joist modeling project at Oregon State University that was also completed for CORRIM. The burdens of the input products are brought into the I-joist system and are added to provide the total output. Primary data was obtained through comprehensive surveys of I-joist manufacturers while secondary data was obtained for the manufacture and delivery of phenol-formaldehyde resin (ATHENA 1993), energy, and electricity (Franklin Associates 1998a-j; Pré Consultants 2001; USDOE 2001) and hot press emissions (NCASI 1999).

Production of I-joists is measured in lineal feet with no measurement for the dimensions of height and width. The shape of the I-joist does not lend itself to any easy form of volume measure. A weighted average of inputs was calculated for producing I-joists in each geographical region studied. The input units of LVL and OSB are given on a volume basis and are used as inputs into I-joist production on this basis. However, since the output value of I-joists only has a linear measurement it is difficult to quantify the other dimensions of the I-joist. There are some assumptions that must be made in order to help scale the inputs for the many different dimensions of I-joists. For that reason, this study focuses on the output of a generic I-joist created from the weighted average of inputs as given on the mill surveys. The unit of output is 1.0 thousand linear feet (MLF) with no regard to flange height and width or OSB web height. Based on the data obtained from the surveys, the generic I-joist in the Pacific Northwest has flange dimensions of roughly 1.3125 inches deep and 1.875 inches wide and a beam depth of 11.75 inches. This I-joist is slightly larger than you would expect to find in that region. In the Southeast, the survey data also results in an I-joist with larger dimensions than one would expect to find in a typical I-joist. The reason for the generic I-joists being larger than typical I-joists is due to the waste and inefficiencies of producing the I-joists are included in the product. This type of generic analysis is typical when I-joists are studied, however, for this report, LCI's for three common I-joist dimensions were completed for each region as well.

For this study the unit of measure was 1,000 lineal feet (MLF), which is consistent with industry practice. This report focuses on two geographic regions of production in the US, the Pacific Northwest and the Southeast. The states in the Pacific Northwest (PNW) region are Oregon and Washington. The states that make up the Southeast (SE) region are Alabama, Arkansas, Florida, Georgia, Louisiana, and Mississippi. This study focused on large-scale production facilities in each region, which would be representative of the industry. The total I-joist production in the PNW for the year 2000 was 212,000 MLF and in the SE the total production for 2000 was 284,000 MLF.

To conduct the survey, mills were identified in each region based on their production capabilities and their representativeness of the industry. Each mill provided data based on I-joists and co-products' production, raw material usage, electricity and fuel usage, emissions, and transportation data for input materials. In the PNW the surveyed mills represented almost 33% of the total production of I-joists for the region. In the SE the mills that were surveyed represented approximately 27% of the total production in that region. The data collected from the mill survey was for the 2000 production year.

A critical review of this LCI process and analysis was conducted to ensure compliance with CORRIM and ISO 14040 protocol.

1.1.1 Black Box Approach

The I-joist manufacturing process was not broken down into unit processes for evaluation. The entire system was modeled as one unit or "black box." This means that all of the energy, fuel, electricity, and resin inputs, as well as all outputs, are lumped together into a single I-joist model. This model was based on the weighted average of the inputs and emissions to generate a generic I-joist that did not have specific dimensions. The reason for using a black box approach is that the I-joist process is fairly simple and does not necessarily lend itself to detailed breakdown analysis. Also, no unit processes of the I-joist process are used in any other LCI project, so it was not necessary to create them. A model of the I-joist manufacturing process and the system boundary is shown in Figure 1.2.

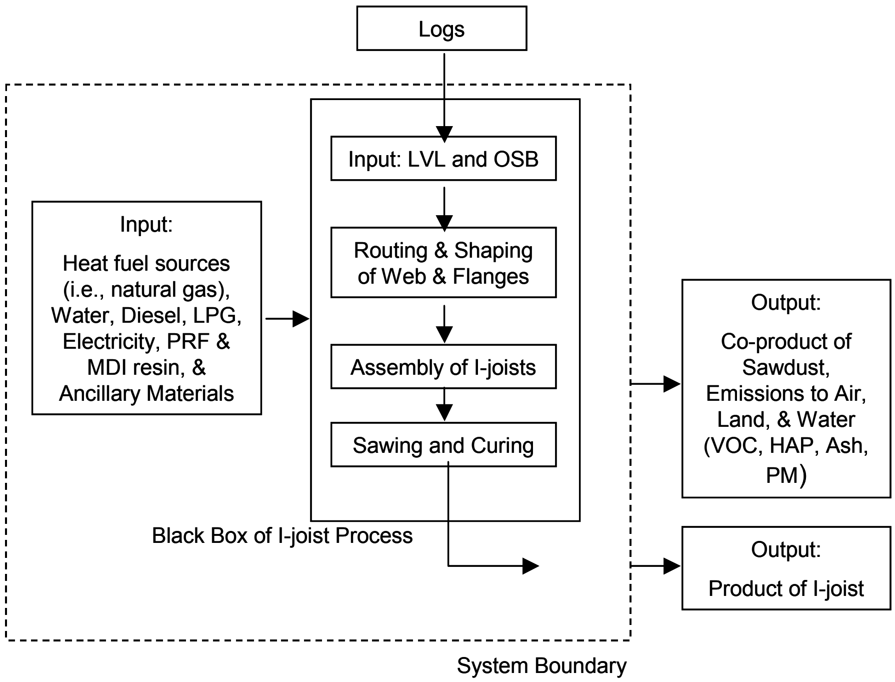

Figure 1.2. Breakdown of Unit Processes in Composite I-joist Manufacturing.

Description of unit processes within "Black Box" process

1. Routing/Shaping of web and flanges: Includes the machining of the OSB web pieces to be fit together at the ends as well as tapered on the top edge so that it can be fitted into the LVL flanges. The LVL flange is routed its entire length to accept the inserted tapered OSB web material. The co-product created during this process is sawdust.

2. Assembly of I-joist: Web and flange material are assembled after resin (usually phenol resorcinol formaldehyde or isocyanate) is applied in web-to-web and web-to-flange joints. Assembly is done mechanically in a continuous fashion.

3. Sawing/Curing: Continuous ribbons of I-joists are cut to proper lengths and in some cases heated in an oven to accelerate resin cure of the joints.

1.1.2 Material Flows

The materials that were used in this LCI for each region are listed in Tables 1.1 and 1.2. Input materials for composite I-joists are laminated veneer lumber, oriented strand board, phenol-formaldehyde resin, and MDI resin. Outputs are limited to the finished I-joists and the co-product sawdust. Co-products are non-product materials that are created during the I-joist manufacturing process and are sold outside of the system boundary. Missing data in the survey was addressed by first contacting the surveyed mill to determine if they had the data, whether it should be considered a zero value, and if truly missing, was excluded in the weighted averaging process based on production capacity. All wood materials are given on an oven-dry weight basis.

Table 1.1. Listing of Input Materials, Product, and Co-product for producing composite I-joists in the Pacific Northwest.

Input Materials	Co-product	Product
Laminated Veneer Lumber	Sawdust	I-joists
Oriented Strand Board		
MDI (isocyanate) Resin		

Table 1.2. Listing of Input Materials, Product, and Co-product for producing composite I-joists in the Southeast.

Input Materials	Co-product	Product
Laminated Veneer Lumber	Sawdust	I-joists
Oriented Strand Board		
MDI (isocyanate) Resin		
Phenol-formaldehyde Resin		

1.1.3 Transportation

Delivery of the input materials was by both truck and train. Large distances were involved with transportation of OSB to the PNW region since there are no plants in that region that produce this composite panel material. The values for LVL shipping distances are zero since the surveyed I-joist plants also produce LVL on-site. The one-way delivery distances for the PNW and the SE are shown in Tables 1.3 and 1.4. The delivery distance and the amount of materials shipped, would be used in any cradle-to-gate LCI analysis for I-joists, in addition to the transportation distances given for the production of OSB and LVL in the Phase I final report.

Table 1.3. Delivery distances (one-way) for composite I-joist production in each region.

Material	PNW Delivery Distance mile	SE Delivery Distance mile
OSB	1,880	320
LVL	0	0
I-joist (PF/ MDI) Resin	0	740
Web Joint (MDI) Resin	292	n/a
Web to Flange (MDI) Resin	147	n/a

The product input weights were based on values for the density of the input products and the amount of those inputs into the manufacturing process. The value for LVL was determined in each region based on the veneer input species density given in the Wood Handbook (FPL 1987) and a 10% increase in weight after resin was added and the product was pressed which would increase the density. The OSB density that was used in this report was obtained from the CORRIM report (Kline 2004) in the section on Southeast oriented strand board production.

1.1.4 Assumptions

The protocol for this LCI study can be found in "Consortium for Research on Renewable Industrial Materials (CORRIM) – research guidelines for life cycle inventories" dated April 10, 2001 and ISO 14040. Other considerations for this report are listed below:

1. A critical external review was conducted of the process and data analysis to ensure compliance with CORRIM and ISO 14040 protocol.

2. Data quality was found to be high based upon comparisons between plants, and on mass and heat balances. Data was also compared between geographical regions and was found to be consistent when accounting for the higher density and moisture contents of wood species of the Southeast.

3. LCI data considered both site and off-site generated emissions to provide a gate-to-gate analysis, and did not include those emissions associated with transportation of materials and the production of logs. To provide a cradle-to-gate LCI, the reader would need to include the environmental impact of the growing and harvesting of trees for logs, the transportation of logs, resins, purchased veneer, hogged fuel, OSB and LVL to the respective mills.

4. The data was collected from the mill survey for the 2000 production year, it was weighted based on the production levels of the participating plants.

5. A mass-allocation process was used for assigning burdens such as emissions.

6. Co-products were defined as those materials that were sold outside the system boundary.

7. Liquid propane gas and diesel fuel were for material transport and split evenly between LVL and I-joist operations, which took place at the same plant.

8. The density values for LVL were based on the density values for the input materials (i.e. veneer) with a 10% increase due to densification and addition of resin during processing. Density values for the wood species, relating to veneer, were obtained from the Wood Handbook–Wood as an Engineering Material (FPL 1987), and based on their estimated weighted percentage. The parallel laminated veneer (PLV) input value for one of the mills was derived from the wood only weight of plywood as determined in the CORRIM Phase I interim report for plywood (2002).

9. Laminated veneer lumber inputs were given on a volume basis of cubic feet (ft^3) and OSB inputs were given on a volume basis of MSF 3/8's (1,000 square feet of surface by 3/8-inch thick).

10. All conversions for forest products are taken from Forest Products Measurements and Conversion Factors, with special emphasis on the US Pacific Northwest (Briggs 1994).

11. SimaPro version 5.0.9, a software package designed to analyze products through their entire life cycle, was used to complete the LCI. Developed in the Netherlands, the software is designed by Pre' Consultants B.V. and contains a database for US materials which include, but are not limited to, paper products, fuels, and chemicals (Pre' Consultants 2001). The US database is provided by Franklin Associates (FAL 1998).

1.2 PRODUCT YIELDS

The input to produce 1,000 linear feet (MLF) of composite I-joists varied between the two regions. The data for the input comes from surveys and has no dimensions other than a linear measure of output. This output should be considered generic for the output of 1.0 MLF of I-joists in each region. I-joists that differ in size will have different input volumes and require further analysis. The LCI data for the three most common I-joist dimensions, which are replacements for structural lumber 2x10's and 2x12's, in each region is included in Appendix 1 to this report. Table 1.4, below, is not specific to these different dimensions and represents weighted data taken directly from mill surveys. It should be noted that the following table gives comparisons based on weight of input materials, which can be deceiving given the product density differences between Pacific Northwest LVL and Southeast LVL. It should also be noted that average flange dimensions from the surveyed plants in the PNW were slightly smaller than those in the SE, leading to the larger LVL input in the SE. However, even with the density and flange size differences, the SE still uses a greater amount of LVL to make their I-joists according to survey data.

Table 1.4. Inputs to produce 1.0 MLF of composite I-joists in each region.

INPUTS		**PNW**	**SE**
Materials	**Units**	**Per MLF[1]**	**Per MLF**
Laminated Veneer Lumber	lb	1.13E+03	1.61E+03
Oriented Strand Board	lb	1.09E+03	1.18E+03
MDI (isocyanate) Resin	lb	1.22E+01	5.20E+00
Phenol-Resorcinol-Formaldehyde Resin	lb	0.00E+00	3.05E+00
Electrical Use			
Electricity	kWh	8.41E+01	7.51E+01
Fuel Use			
Natural Gas	Btu	5.02E+03	6.50E+04
Liquid Propane Gas	Btu	1.50E+04	3.48E+04
Diesel	Btu	1.14E+04	4.14E+04

[1] MLF is one thousand linear feet of generic I-joist

1.3 MANUFACTURING ENERGY SUMMARY

1.3.1 Sources of Energy

Energy for the production of I-joists in the PNW and SE comes from electricity, natural gas, diesel, and liquid propane gas (LPG). None of the plants that were surveyed used hogged fuel (wood and bark waste fuel) as a source of energy in the manufacturing process. The electricity in the plant is used to run the various saws and assembly machinery in the I-joist plant. The natural gas is used to generate heat in order to cure the resin used in the I-joist assembly. The diesel fuel and LPG are used to operate the equipment that moves the input material and output product around the manufacturing facility.

1.3.2 Electricity Use Summary

The source and type of fuel used to generate electricity for the manufacturing of I-joists is very vital to conduct a thorough LCI analysis. Each region that was analyzed had its own unique and different sources of electricity generation. The breakdown of electricity for the PNW is shown in Table 1.5 and the breakdown for electricity in the SE is shown in Table 1.6. The data is obtained from the US Department of Energy (USDOE) for the year 2000 (USDOE 2001). In the PNW, the dominant form of energy is hydro making up 74.3% of the total. In the SE, the dominant form of fuel for electricity is coal at 45.56% followed by gas (23.03%) and nuclear (21.57%) respectively. In the SimaPro (LCI) software, no burdens are assessed for hydroelectricity generation, but considerable burdens are associated with the combustion of coal and other fossil fuels, as well as for nuclear power generation.

Table 1.5. Electricity generation by primary energy sources and state for the Pacific Northwest region as defined by the US Department of Energy.

Percentage Share, 2000			
Fuel Source	**OR**	**WA**	**Average**
Coal	7.4	8.8	8.1
Petroleum	0.1	0.4	0.25
Natural Gas	17.1	7.5	12.3
Nuclear	0	7.9	3.95
Hydro	74.3	74.3	74.3
Other	1.1	1.1	1.1

Source: www.eia.doe.gov/cneaf/electricity/st_profiles/toc.html

Table 1.6. Electricity generation by primary energy sources and state for the Southeast region as defined by the US Department of Energy.

Percentage Share, 2000								
Fuel Source	**AL**	**AR**	**FL**	**GA**	**LA**	**MS**	**TX**	**Average**
Coal	61.90	64.80	25.60	37.00	37.90	54.70	37.00	45.56
Petroleum	0.20	1.30	2.30	7.90	18.50	0.50	0.70	4.49
Gas	4.30	2.70	49.60	22.50	22.70	7.80	51.60	23.03
Nuclear	25.20	26.40	17.60	28.50	16.90	26.50	9.90	21.57
Hydro	4.70	1.90	0.60	0.00	0.00	5.40	0.20	1.83
Other	3.70	2.90	4.30	4.10	4.00	5.10	0.60	3.53

Source: www.eia.doe.gov/cneaf/electricity/st_profiles/toc.html

Since the project was completed in black box format, there was no need to do a breakdown of electricity use by unit process. Also, since no hogged fuel is used in this process, there is no need to complete a hogged fuel utilization analysis.

1.4 ADHESIVE USAGE AND ENERGY/ELECTRICITY TO PRODUCE RESINS

In the Pacific Northwest, the only type of resin used by the plants in our survey to make I-joists was methyl diphenyl isocyanate (MDI) resin. In the Southeast, the plants used both MDI and phenol-resorcinol-formaldehyde (PRF) resin to manufacture I-joists. There is LCI data from Boustead Consulting as part of a SimaPro database (Pré Consultants B.V. 2001) on MDI resin, but the LCI data used for PRF resin is the data for phenol-formaldehyde (PF) resin. The data for phenol-formaldehyde resin was obtained from ATHENA™ in a report on structural wood products (ATHENA 1993). In the PNW the amount of MDI resin needed to manufacture 1.0 MLF of I-joists was 12.24 lbs. Table 1.7 shows the type and quantity of materials, electricity and fuels required to produce the 12.24 lbs. of MDI resin necessary to make the I-joists.

Table 1.7. LCI data for the production of 12.24 lb of MDI resin needed to manufacture 1.0 MLF of composite I-joists in the Pacific Northwest.

Input Energy	Input Btu	Usage Classification
Energy from coal	1.58E+04	Fuel production and delivery of energy
Energy from oil	5.95E+03	Fuel production and delivery of energy
Energy from natural gas	2.09E+04	Fuel production and delivery of energy
Energy from hydro power	1.58E+03	Fuel production and delivery of energy
Energy from uranium	1.96E+04	Fuel production and delivery of energy
Energy from lignite	5.37E+03	Fuel production and delivery of energy
Energy from biomass	1.58E+02	Fuel production and delivery of energy
Energy from hydrogen	1.79E-13	Fuel production and delivery of energy
Energy (undefined)	3.16E+02	Fuel production and delivery of energy
Energy from peat	1.05E+01	Fuel production and delivery of energy
Energy from coal	2.92E+04	Energy content of delivered fuel
Energy from oil	4.21E+04	Energy content of delivered fuel
Energy from natural gas	1.82E+05	Energy content of delivered fuel
Energy from hydro power	1.10E+03	Energy content of delivered fuel
Energy from uranium	9.37E+03	Energy content of delivered fuel
Energy from lignite	2.74E+03	Energy content of delivered fuel
Energy from sulphur	1.05E+02	Energy content of delivered fuel
Energy from biomass	5.26E+01	Energy content of delivered fuel
Energy from hydrogen	5.10E+03	Energy content of delivered fuel
Energy recovered	-2.44E+04	Energy content of delivered fuel
Energy (undefined)	2.10E+02	Energy content of delivered fuel
Energy from peat	5.26E+00	Energy content of delivered fuel
Energy from coal	5.26E+01	Fuel use in transport
Energy from oil	2.10E+03	Fuel use in transport
Energy from natural gas	2.10E+02	Fuel use in transport
Energy from hydro power	2.10E+00	Fuel use in transport
Energy from uranium	2.10E+01	Fuel use in transport
Energy from lignite	1.89E-01	Fuel use in transport
Energy from sulphur	1.89E-02	Fuel use in transport
Energy from biomass	1.42E-01	Fuel use in transport
Energy from hydrogen	1.79E-16	Fuel use in transport
Energy recovered	-2.10E-02	Fuel use in transport
Energy (undefined)	2.74E-01	Fuel use in transport
Energy from peat	1.68E-06	Fuel use in transport

Energy from coal	2.26E+03	Feedstock energy
Energy from oil	7.65E+04	Feedstock energy
Energy from natural gas	1.02E+05	Feedstock energy
Energy from wood	1.89E+01	Feedstock energy
Energy from sulphur	1.21E+02	Feedstock energy
Energy from biomass	3.21E-02	Feedstock energy

Input Material	**Input lb**	**Usage Classification**
Baryte	2.23E-03	
Bauxite	2.63E-03	
NaCl	5.77E+00	
Calcium sulphate	1.20E-04	
Chalk	1.42E-28	
Clay minerals	1.34E-04	
Feldspar	1.84E-34	
Ferromanganese	7.22E-06	
Flourspar	3.94E-05	
Iron (in ore)	8.53E-03	
Lead (in ore)	2.23E-05	
Limestone	2.45E-01	
Nickel (in ore)	1.35E-06	
Rutile	2.08E-28	
Sand	1.01E-02	
Zinc (in ore)	6.98E-07	
Phosphate (as P_2O_5)	8.81E-05	
Sulphur (elemental)	6.00E-02	
Dolomite	5.30E-04	
Chromium (in ore)	8.57E-12	
Oxygen	1.84E+00	
Nitrogen	1.55E+00	
Air	5.15E+00	
Bentonite	1.21E-03	
Gravel	2.72E-05	
Olivine	7.29E-05	
Shale	3.41E-04	
Granite	2.94E-07	
KCl	1.58E-01	
Sulphur (bonded)	2.99E-02	
Water (surface, for cooling)	1.89E+03	Water for cooling
Water (sea, for cooling)	1.27E+03	Water for cooling
Water (cooling)	2.19E+02	Water for cooling
Water (well, for cooling)	6.01E-02	Water for cooling
Water (drinking, for process.)	1.00E+03	Water for processing
Water (surface, for process.)	1.36E+01	Water for processing
Water (sea, for processing)	4.54E+00	Water for processing
Water (processing)	7.35E+00	Water for processing
Water (well, for processing)	4.41E-01	Water for processing

As was mentioned earlier, in the SE the I-joist plants used a combination of PRF resin and MDI resins to make I-joists. Table 1.8 shows the material and energy/electricity requirements to produce the 5.2 lbs of MDI resin needed to make 1.0 MLF of I-joists. Table 1.9 shows the material and energy/electricity to produce the 3.05 lbs of PRF (PF is substituted here) resin to make 1.0 MLF of I-joists. Phenol-formaldehyde resin is made up of 65% formaldehyde and 35% phenol. The emissions for producing each type of resin are included in Tables 1.10 and 1.11.

Table 1.8. LCI data for the production of 5.2 lb of MDI resin needed to manufacture 1.0 MLF of composite I-joists in the Southeast.

Input Energy	Input Btu	Usage Classification
Energy from coal	6.73E+03	Fuel production and delivery of energy
Energy from oil	2.53E+03	Fuel production and delivery of energy
Energy from natural gas	8.90E+03	Fuel production and delivery of energy
Energy from hydro power	6.71E+02	Fuel production and delivery of energy
Energy from uranium	8.35E+03	Fuel production and delivery of energy
Energy from lignite	2.28E+03	Fuel production and delivery of energy
Energy from biomass	6.71E+01	Fuel production and delivery of energy
Energy from hydrogen	7.61E-14	Fuel production and delivery of energy
Energy (undefined)	1.34E+02	Fuel production and delivery of energy
Energy from peat	4.47E+00	Fuel production and delivery of energy
Energy from coal	1.24E+04	Energy content of delivered fuel
Energy from oil	1.79E+04	Energy content of delivered fuel
Energy from natural gas	7.72E+04	Energy content of delivered fuel
Energy from hydro power	4.70E+02	Energy content of delivered fuel
Energy from uranium	3.98E+03	Energy content of delivered fuel
Energy from lignite	1.16E+03	Energy content of delivered fuel
Energy from sulphur	4.47E+01	Energy content of delivered fuel
Energy from biomass	2.24E+01	Energy content of delivered fuel
Energy from hydrogen	2.17E+03	Energy content of delivered fuel
Energy recovered	-1.04E+04	Energy content of delivered fuel
Energy (undefined)	8.95E+01	Energy content of delivered fuel
Energy from peat	2.24E+00	Energy content of delivered fuel
Energy from coal	2.24E+01	Fuel use in transport
Energy from oil	8.95E+02	Fuel use in transport
Energy from natural gas	8.95E+01	Fuel use in transport
Energy from hydro power	8.95E-01	Fuel use in transport
Energy from uranium	8.95E+00	Fuel use in transport
Energy from lignite	8.05E-02	Fuel use in transport
Energy from sulphur	8.05E-03	Fuel use in transport
Energy from biomass	6.04E-02	Fuel use in transport
Energy from hydrogen	7.61E-17	Fuel use in transport
Energy recovered	-8.95E-03	Fuel use in transport
Energy (undefined)	1.16E-01	Fuel use in transport
Energy from peat	7.16E-07	Fuel use in transport
Energy from coal	9.62E+02	Feedstock energy
Energy from oil	3.25E+04	Feedstock energy
Energy from natural gas	4.32E+04	Feedstock energy
Energy from wood	8.05E+00	Feedstock energy
Energy from sulphur	5.15E+01	Feedstock energy
Energy from biomass	1.36E-02	Feedstock energy

Input Material	Input (lb)	Usage Classification
Baryte	9.49E-04	
Bauxite	1.12E-03	
NaCl	2.45E+00	
Calcium sulphate	5.12E-05	
Chalk	6.04E-29	
Clay minerals	5.71E-05	
Feldspar	7.81E-35	
Ferromanganese	3.07E-06	
Flourspar	1.68E-05	
Iron (in ore)	3.63E-03	
Lead (in ore)	9.47E-06	
Limestone	1.04E-01	
Nickel (in ore)	5.72E-07	
Rutile	8.85E-29	
Sand	4.27E-03	
Zinc (in ore)	2.97E-07	
Phosphate (as P_2O_5)	3.75E-05	
Sulphur (elemental)	2.55E-02	
Dolomite	2.25E-04	
Chromium (in ore)	3.64E-12	
Oxygen	7.81E-01	
Nitrogen	6.61E-01	
Air	2.19E+00	
Bentonite	5.15E-04	
Gravel	1.16E-05	
Olivine	3.10E-05	
Shale	1.45E-04	
Granite	1.25E-07	
KCl	6.70E-02	
Sulphur (bonded)	1.27E-02	
Water (surface, for cooling)	8.05E+02	Water for cooling
Water (sea, for cooling)	5.40E+02	Water for cooling
Water (cooling)	9.30E+01	Water for cooling
Water (well, for cooling)	2.56E-02	Water for cooling
Water (drinking, for process.)	4.27E+02	Water for processing
Water (surface, for process.)	5.78E+00	Water for processing
Water (sea, for processing)	1.93E+00	Water for processing
Water (processing)	3.13E+00	Water for processing
Water (well, for processing)	1.88E-01	Water for processing

Table 1.9. LCI data for the production of 3.05 lbs of PRF (using PF data) resin needed to manufacture 1.0 MLF of composite I-joists in the Southeast.

INPUTS		
Materials	**Units**	**per MLF**
Formaldehyde	lb	1.98E+00
Phenol	lb	1.07E+00
Fuel Use		
Heavy oil	Btu	1.90E+03
Gasoline	Btu	1.31E+01
Natural gas	Btu	3.53E+04
Electricity Use		
Electricity	kWh	1.96E+00

Emissions from resin production are key elements in the total output of life cycle emissions data for composite I-joists. The following Tables 1.10 and 1.11 represent the air emissions associated with generating the required resins to produce 1.0 MLF of I-joists in each region. In the PNW the only resin reported on our surveys was MDI (which may not always be the case in the PNW); however in the SE both MDI and PRF are used to make I-joists. The outputs for the south include emissions from the production of MDI and PRF in the same table. Due to the lack of an LCI for PRF resin, PF resin was used as a substitute. Also included in the tables are the total allocated emissions for producing the I-joists and the percentage of total emissions that are contributed to the process by the resins. The total allocated emissions, that include site and off-site emissions, can also be referred to at the cumulative allocated emissions.

Table 1.10. Air emissions for the production of 12.24 lbs of MDI resin needed to produce 1.0 MLF of I-joists in the Pacific Northwest.

Air Emission	MDI Resin Production lb	Total Allocated Emissions Per MLF of I-joists Production lb	MDI Resin Contribution to Total Allocated Emissions for I-joist Production %
1,2-dichloroethane	3.19E-10	4.42E-10	72.0
Aldehydes	1.91E-05	4.57E-03	0.4
Ammonia	4.96E-04	3.20E-03	15.5
CFC (soft)	3.54E-05	4.92E-05	71.9
Cl_2	7.36E-06	1.00E-03	0.7
CO	3.42E-02	4.70E+00	0.7
CO_2[1]	4.13E+01	6.73E+01	61.4
CO_2 (biomass)	6.14E-02	8.68E+02	0.01
CS_2	3.05E-09	4.24E-09	71.9
C_xH_y	4.89E-02	6.78E-02	72.1
C_xH_y aromatic	8.88E-04	1.23E-03	72.2
C_xH_y chloro	1.49E-04	2.07E-04	71.9
Dust	5.79E-02	8.04E-02	72.1
F_2	3.36E-08	4.67E-08	71.9
H_2	2.20E-02	3.06E-02	72.0
H_2S	6.32E-06	8.78E-06	71.9
H_2SO_4	1.95E-04	2.71E-04	71.9
HCl	1.65E-03	2.10E-02	7.9
HCN	6.97E-34	9.69E-34	72.0
HF	7.39E-05	2.71E-03	2.7
Hg	4.96E-06	1.50E-05	33.0
Mercaptans	8.88E-07	1.24E-06	71.8
Metals	8.36E-05	2.01E-04	41.7
Methane	2.18E-01	1.77E+00	12.3
N_2O	1.56E-06	2.18E-03	0.1
NO_x	1.85E-01	4.13E+00	4.5
Organic substances	7.77E-04	2.69E-02	2.9
Pb	2.44E-09	1.68E-04	0.0
SO_x	1.79E-01	7.07E+00	2.5
Vinyl chloride	3.18E-10	4.41E-10	72.0

[1]CO_2 fossil and non-fossil combined

Table 1.11. Air emissions for the production of the 5.2 lbs of MDI resin and the 3.05 lbs of PRF resin needed to produce 1.0 MLF of I-joists in the Southeast.

Air Emission	MDI & PF Resin Production lb	I-joist Production lb/MLF	MDI & PF Resin Contribution to Total for I-joist production %
1,2-dichloroethane	1.35E-10	3.01E-10	44.98
Acrolein	3.86E-08	3.89E-02	0.00
Aldehydes	1.78E-04	6.20E-03	2.86
Ammonia	2.39E-04	4.15E-03	5.76
As	1.55E-07	4.71E-05	0.33
Be	1.41E-08	2.55E-06	0.55
Benzene	2.18E-06	8.78E-04	0.25
Cd	1.37E-07	1.99E-05	0.69
CFC (soft)	1.50E-05	3.35E-05	44.91
Cl_2	3.61E-06	1.81E-03	0.20
CO	4.36E-02	6.82E+00	0.64
CO_2	1.75E+01	4.97E+01	35.30
CO_2 (biomass)	2.61E-02	1.11E+03	0.00
CO_2 (fossil)	9.51E+00	9.51E+02	1.00
CO_2 (non-fossil)	4.62E-03	6.21E+01	0.01
Cobalt	1.47E-07	2.26E-05	0.65
Cr	1.91E-07	4.38E-05	0.44
CS_2	1.30E-09	2.88E-09	44.94
Cumene	1.82E-05	3.66E-04	4.96
C_xH_y	2.08E-02	4.62E-02	45.03
C_xH_y aromatic	3.77E-04	8.41E-04	44.89
C_xH_y chloro	6.33E-05	1.41E-04	44.90
Dichloromethane	1.56E-07	3.13E-05	0.50
Dioxin (TEQ)	2.05E-13	4.10E-11	0.50
Dust	2.46E-02	5.48E-02	44.93
F_2	1.43E-08	3.18E-08	44.95
Formaldehyde	4.11E-03	1.85E-01	2.22
H_2	9.36E-03	2.09E-02	44.86
H_2S	2.68E-06	5.98E-06	44.86
H_2SO_4	8.27E-05	1.84E-04	44.86
HCl	8.95E-04	4.04E-02	2.22
HCN	2.96E-34	6.60E-34	44.90
HF	5.82E-05	5.46E-03	1.06
Hg	2.20E-06	2.18E-05	10.11
Kerosene	1.18E-06	2.40E-04	0.49
Mercaptans	3.77E-07	8.41E-07	44.89
Metals	3.74E-05	2.21E-04	16.90
Methane	1.24E-01	2.60E+00	4.76
Mn	3.27E-07	2.12E-03	0.02
N-nitrodimethylamine	8.15E-09	7.74E-03	0.00
N_2O	2.33E-05	4.54E-03	0.51
Naphthalene	7.70E-09	5.52E-04	0.00
Ni	1.90E-06	4.03E-04	0.47

NO_x	1.71E-01	6.01E+00	2.84
Non methane VOC	7.52E-02	2.94E+00	2.56
Organic substances	4.86E-04	4.59E-02	1.06
Particulates	6.99E-04	6.90E-01	0.10
Particulates (PM10)	5.51E-04	1.36E+00	0.04
Particulates (unspecified)	3.27E-03	5.52E-01	0.59
Pb	2.02E-07	3.09E-04	0.07
Phenol	5.31E-03	1.36E-01	3.89
Sb	5.57E-08	8.85E-06	0.63
Se	3.18E-07	6.14E-05	0.52
SO_x	2.30E-01	1.08E+01	2.12
Tetrachloroethene	3.74E-08	7.52E-06	0.50
Tetrachloromethane	1.06E-07	2.04E-05	0.52
Trichloroethene	3.65E-08	7.33E-06	0.50
Vinyl chloride	1.35E-10	3.00E-10	44.94

Notes: Total emissions include both site generated and off-site generated emissions.

1.5 I-JOIST PROCESS RELATED EMISSIONS

The black box approach eliminates the need to break down emissions for each unit process within the I-joist manufacturing process. However, it is useful to determine what emissions the I-joist plant generates and which emissions show up as a result of producing the input materials. The emissions can be broken down into site-generated or the I-joist process related emissions and off-site generated or input materials related emissions, when both are combined they provide the total or cumulative emissions. The emissions listed in the following tables include those of the total allocated emissions related to the production of I-joist, LVL, OSB, electricity, fuel, and adhesive, but exclusive of transportation of input materials and the generation of logs. The mass-based allocation of emissions for I-joist in the PNW is 89.8% with the remainder going toward sawdust, a co-product. In the SE the mass-based allocation of emissions to I-joist is higher at 93% while the rest of the emissions are allocated to sawdust. Tables 1.12 and 1.13 give breakdowns of the allocated emissions in terms of those attributed to the production of LVL and OSB, and those as a result of the emissions during the I-joist manufacturing process. Transportation emissions are not included in this report for wood-based inputs or resin. They are added for the final cradle-to-grave analysis completed by CORRIM (CORRIM 2004) to include transportation and the production of logs.

Table 1.12. Air emissions generated from producing 1.0 MLF of I-joists in the Pacific Northwest region.

Air Emission	LVL and OSB Input Product Contribution lb/MLF	I-joist Process (Site) Contribution lb/MLF	TOTAL Allocated Emissions lb/MLF	LVL and OSB Contribution to TOTAL Alloc. %
1,2-dichloroethane	1.57E-10	2.86E-10	4.42E-10	35.44
Acetaldehyde	1.08E-01	5.13E-04	1.09E-01	99.53
Acetone	1.11E-02	1.71E-04	1.13E-02	98.48
Acrolein	3.47E-02	0.00E+00	3.47E-02	100.00
Aldehydes	4.44E-03	1.25E-04	4.57E-03	97.25
Alpha-pinene	5.93E-02	0.00E+00	5.93E-02	100.00
Ammonia	2.43E-03	7.64E-04	3.20E-03	76.11
As	2.31E-05	6.84E-07	2.38E-05	97.13
Ash	1.32E-04	0.00E+00	1.32E-04	100.00
Ba	5.53E-04	0.00E+00	5.53E-04	100.00
Be	1.14E-06	6.84E-08	1.21E-06	94.34
Benzene	4.96E-04	5.70E-07	4.96E-04	99.89
Beta-pinene	2.30E-02	0.00E+00	2.30E-02	100.00
Cd	8.81E-06	2.51E-07	9.06E-06	97.23
CFC (soft)	1.74E-05	3.18E-05	4.92E-05	35.42
Cl_2	9.97E-04	6.55E-06	1.00E-03	99.35
CO	4.62E+00	7.98E-02	4.70E+00	98.30
CO_2	2.98E+01	3.74E+01	6.73E+01	44.32
CO_2 (biomass)	8.68E+02	0.00E+00	8.68E+02	100.00
CO_2 (fossil)	5.31E+02	3.36E+01	5.64E+02	94.04
CO_2 (non-fossil)	1.87E+01	1.60E-02	1.88E+01	99.91
Cobalt	9.98E-06	3.93E-07	1.04E-05	96.21
Cr	2.07E-05	9.12E-07	2.17E-05	95.79
CS_2	1.50E-09	2.74E-09	4.24E-09	35.35
Cumene	3.38E-04	0.00E+00	3.38E-04	100.00
C_xH_y	2.40E-02	4.38E-02	6.78E-02	35.38
C_xH_y aromatic	4.37E-04	7.95E-04	1.23E-03	35.46
C_xH_y chloro	7.30E-05	1.34E-04	2.07E-04	35.26
Dichloromethane	1.41E-05	9.92E-07	1.50E-05	93.41
Dioxin (TEQ)	1.85E-11	1.32E-12	1.98E-11	93.33
Dust	2.85E-02	5.19E-02	8.04E-02	35.46
F_2	1.65E-08	3.02E-08	4.67E-08	35.37
Fe	5.53E-04	0.00E+00	5.53E-04	100.00
Formaldehyde	1.80E-01	7.98E-04	1.81E-01	99.56
H_2	1.08E-02	1.98E-02	3.06E-02	35.38
H_2S	3.11E-06	5.67E-06	8.78E-06	35.45
H_2SO_4	9.58E-05	1.75E-04	2.71E-04	35.37
HCl	1.84E-02	2.67E-03	2.10E-02	87.29
HCN	3.43E-34	6.26E-34	9.69E-34	35.41
HF	2.47E-03	2.40E-04	2.71E-03	91.14
Hg	1.01E-05	4.94E-06	1.50E-05	67.16
K	9.80E-02	0.00E+00	9.80E-02	100.00
Kerosene	1.09E-04	7.41E-06	1.16E-04	93.63
Limonene	6.67E-03	0.00E+00	6.67E-03	100.00

MDI (isocyanate)	1.18E-04	0.00E+00	1.18E-04	100.00
Mercaptans	4.37E-07	8.00E-07	1.24E-06	35.30
Metals	1.21E-04	7.99E-05	2.01E-04	60.20
Methane	1.50E+00	2.70E-01	1.77E+00	84.79
Methanol	4.19E-01	1.54E-02	4.34E-01	96.46
Methyl ethyl ketone	5.26E-04	0.00E+00	5.26E-04	100.00
Methyl i-butyl ketone	4.29E-04	0.00E+00	4.29E-04	100.00
Mn	1.16E-03	0.00E+00	1.16E-03	100.00
N-nitrodimethylamine	6.90E-03	0.00E+00	6.90E-03	100.00
N_2O	2.04E-03	1.41E-04	2.18E-03	93.55
Na	2.26E-03	0.00E+00	2.26E-03	100.00
Naphthalene	3.02E-04	2.12E-07	3.02E-04	99.93
Ni	1.91E-04	3.99E-06	1.95E-04	97.95
Non methane VOC	2.13E+00	8.55E-02	2.22E+00	96.14
NO_x	3.78E+00	3.42E-01	4.13E+00	91.71
Organic substances	2.60E-02	8.61E-04	2.69E-02	96.80
Particulates	8.42E-01	1.14E-03	8.44E-01	99.86
Particulates (PM10)	2.79E-01	3.53E-03	2.82E-01	98.75
Particulates (unspecified)	2.59E-01	1.78E-02	2.77E-01	93.58
Pb	1.67E-04	9.12E-07	1.68E-04	99.46
Phenol	1.25E-01	5.70E-05	1.25E-01	99.95
Propionaldehyde	4.39E-04	0.00E+00	4.39E-04	100.00
Sb	3.91E-06	1.66E-07	4.08E-06	95.92
Se	2.77E-05	1.94E-06	2.96E-05	93.44
SO_2	1.77E-01	1.71E-05	1.77E-01	99.99
SO_x	6.56E+00	5.13E-01	7.07E+00	92.74
Tetrachloroethene	3.38E-06	2.40E-07	3.62E-06	93.37
Tetrachloromethane	8.73E-06	3.93E-07	9.12E-06	95.69
THC as Carbon	1.27E-01	0.00E+00	1.27E-01	100.00
Trichloroethene	3.31E-06	2.34E-07	3.54E-06	93.38
Vinyl chloride	1.56E-10	2.85E-10	4.41E-10	35.40
VOC	2.22E+00	0.00E+00	2.22E+00	100.00
Zn	5.54E-04	9.12E-08	5.54E-04	99.98

Notes: Includes site generated and off-site generated emissions; these are the cumulative allocated emissions.

Table 1.13. Air emissions generated from producing 1.0 MLF of I-joists in the Southeast region.

Air Emission	LVL and OSB Input Product Contribution lb/MLF	I-joist Process Contribution lb/MLF	TOTAL Allocated Emissions lb/MLF	LVL and OSB Contribution to TOTAL Alloc. %
1,2-dichloroethane	1.76E-10	1.25E-10	3.01E-10	58.33
Acetaldehyde	1.10E-01	0.00E+00	1.10E-01	100.00
Acetone	3.25E-02	1.48E-04	3.26E-02	99.55
Acrolein	3.89E-02	0.00E+00	3.89E-02	100.00
Aldehydes	5.54E-03	6.64E-04	6.20E-03	89.30
Ammonia	3.36E-03	7.97E-04	4.15E-03	80.82
As	4.26E-05	4.43E-06	4.71E-05	90.60
Ash	1.48E-04	0.00E+00	1.48E-04	100.00
Ba	1.01E-03	0.00E+00	1.01E-03	100.00
Be	2.12E-06	4.28E-07	2.55E-06	83.24
Benzene	8.76E-04	1.40E-06	8.78E-04	99.84
Cd	1.67E-05	3.17E-06	1.99E-05	84.07
CFC (soft)	1.95E-05	1.39E-05	3.35E-05	58.37
Cl_2	1.81E-03	2.95E-06	1.81E-03	99.84
CO	6.65E+00	1.70E-01	6.82E+00	97.51
CO_2	3.34E+01	1.63E+01	4.97E+01	67.21
CO_2 (biomass)	1.11E+03	3.69E+00	1.11E+03	99.67
CO_2 (fossil)	8.16E+02	1.35E+02	9.51E+02	85.81
CO_2 (non-fossil)	6.21E+01	4.72E-02	6.21E+01	99.92
Cobalt	1.89E-05	3.69E-06	2.26E-05	83.66
Cr	3.83E-05	5.53E-06	4.38E-05	87.37
CS_2	1.68E-09	1.20E-09	2.88E-09	58.31
Cumene	3.50E-04	1.62E-05	3.66E-04	95.56
C_xH_y	2.69E-02	1.92E-02	4.62E-02	58.31
C_xH_y aromatic	4.89E-04	3.52E-04	8.41E-04	58.16
C_xH_y chloro	8.19E-05	5.90E-05	1.41E-04	58.12
Dichloromethane	2.60E-05	5.31E-06	3.13E-05	83.02
Dioxin (TEQ)	3.41E-11	6.93E-12	4.10E-11	83.09
Dust	3.19E-02	2.29E-02	5.48E-02	58.28
F_2	1.85E-08	1.33E-08	3.18E-08	58.24
Fe	1.01E-03	0.00E+00	1.01E-03	100.00
Formaldehyde	1.79E-01	5.97E-03	1.85E-01	96.77
H_2	1.22E-02	8.70E-03	2.09E-02	58.30
H_2S	3.49E-06	2.49E-06	5.98E-06	58.32
H_2SO_4	1.08E-04	7.67E-05	1.84E-04	58.40
HCl	3.32E-02	7.23E-03	4.04E-02	82.12
HCN	3.85E-34	2.75E-34	6.60E-34	58.32
HF	4.51E-03	9.51E-04	5.46E-03	82.59
Hg	1.69E-05	4.82E-06	2.18E-05	77.83
K	1.79E-01	0.00E+00	1.79E-01	100.00
Kerosene	2.00E-04	4.06E-05	2.40E-04	83.13
MDI (isocyanate)	1.32E-04	0.00E+00	1.32E-04	100.00
Mercaptans	4.90E-07	3.51E-07	8.41E-07	58.25
Metals	1.68E-04	5.30E-05	2.21E-04	76.03

Methane	2.21E+00	3.84E-01	2.60E+00	85.23
Methanol	4.50E-01	1.55E-02	4.65E-01	96.67
Mn	2.11E-03	1.11E-05	2.12E-03	99.48
N-nitrodimethylamine	7.74E-03	0.00E+00	7.74E-03	100.00
N_2O	3.77E-03	7.74E-04	4.54E-03	82.95
Na	4.13E-03	0.00E+00	4.13E-03	100.00
Naphthalene	5.51E-04	3.36E-07	5.52E-04	99.94
Ni	3.58E-04	4.43E-05	4.03E-04	89.01
Non methane VOC	2.65E+00	2.88E-01	2.94E+00	90.20
NO_x	5.23E+00	7.82E-01	6.01E+00	86.99
Organic substances	4.49E-02	1.04E-03	4.59E-02	97.74
Particulates	6.69E-01	2.06E-02	6.90E-01	97.01
Particulates (PM10)	1.31E+00	5.30E-02	1.36E+00	96.12
Particulates (unspecified)	4.68E-01	8.41E-02	5.52E-01	84.78
Pb	3.04E-04	5.09E-06	3.09E-04	98.35
Phenol	1.32E-01	4.65E-03	1.36E-01	96.59
Sb	7.37E-06	1.48E-06	8.85E-06	83.25
Se	5.10E-05	1.03E-05	6.14E-05	83.17
SO_2	1.98E-01	0.00E+00	1.98E-01	100.00
SO_x	9.52E+00	1.32E+00	1.08E+01	87.82
Tetrachloroethene	6.23E-06	1.29E-06	7.52E-06	82.84
Tetrachloromethane	1.70E-05	3.39E-06	2.04E-05	83.33
Trichloroethene	6.08E-06	1.25E-06	7.33E-06	83.00
Vinyl chloride	1.75E-10	1.25E-10	3.00E-10	58.23
VOC	1.90E+00	0.00E+00	1.90E+00	100.00
Water vapor	6.49E+02	0.00E+00	6.49E+02	100.00
Zn	1.01E-03	0.00E+00	1.01E-03	100.00

Notes: Includes site generated and off-site generated emissions; these are also referred to as cumulative allocated emissions.

1.6 SUMMARY OF I-JOIST RELATED AIR EMISSIONS

The total air emissions for producing 1.0 MLF of I-joist in each geographical region are allocated based on the fraction of I-joist to the total weight of I-joists and co-products—a mass-based allocation. Tables 1.14 and 1.15 give summaries of the air emissions for each region of production. As mentioned earlier, the allocation for I-joists in the PNW is 89.8% and in the Southeast it is 93%. The data does not include emissions for transportation or for the production of logs from forest resources.

Table 1.14. Total allocated air emission summaries for 1.0 MLF of composite I-joists produced in the Pacific Northwest region.

Air Emissions	I-joists lb/MLF	I-joists kg/10³m[1]	Air Emissions	I-joists lb/MLF	I-joists kg/ 10³m[1]
1,2-dichloroethane	4.41E-10	6.56E-10	HF	2.69E-03	4.00E-03
Accetaldehyde	1.08E-01	1.61E-01	Hg	1.50E-05	2.23E-05
Acetone	1.12E-02	1.67E-02	K	9.75E-02	1.45E-01
Acrolein	3.45E-02	5.13E-02	Kerosene	1.16E-04	1.73E-04
Aldehydes	4.54E-03	6.76E-03	Limonene	6.61E-03	9.84E-03
Alpha-pinene	5.87E-02	8.74E-02	MDI (isocyanate)	1.17E-04	1.75E-04
Ammonia	3.19E-03	4.74E-03	Mercaptans	1.23E-06	1.83E-06
As	2.37E-05	3.53E-05	Metals	2.00E-04	2.97E-04
Ash	1.31E-04	1.95E-04	Methane	1.77E+00	2.63E+00
Ba	5.50E-04	8.18E-04	Methanol	4.33E-01	6.44E-01
Be	1.20E-06	1.79E-06	Methyl ethyl ketone	5.23E-04	7.79E-04
Benzene	4.94E-04	7.35E-04	Methyl I-butyl ketone	4.27E-04	6.35E-04
Beta-pinene	2.29E-02	3.40E-02	Mn	1.16E-03	1.72E-03
Cd	9.06E-06	1.35E-05	N-nitrodimethylamine	6.84E-03	1.02E-02
CFC (soft)	4.90E-05	7.29E-05	N_2O	2.17E-03	3.23E-03
Cl_2	9.98E-04	1.48E-03	Na	2.25E-03	3.35E-03
CO	4.68E+00	6.96E+00	Naphthalene	3.01E-04	4.48E-04
CO_2	6.67E+01	9.92E+01	Ni	1.94E-04	2.88E-04
CO_2 (biomass)	8.66E+02	1.29E+03	Non methane VOC	2.21E+00	3.28E+00
CO_2 (fossil)	5.61E+02	8.35E+02	NO_x	4.11E+00	6.12E+00
CO_2 (non-fossil)	1.86E+01	2.77E+01	Organic substances	2.68E-02	3.99E-02
Cobalt	1.04E-05	1.54E-05	Particulates	8.49E-01	1.26E+00
Cr	2.15E-05	3.21E-05	Particulates (PM10)	2.81E-01	4.18E-01
CS_2	4.22E-09	6.28E-09	Particulates (unspfd)	2.67E-01	3.97E-01
Cumene	3.36E-04	5.00E-04	Pb	1.67E-04	2.49E-04
C_xH_y	6.73E-02	1.00E-01	Phenol	1.24E-01	1.85E-01
C_xH_y aromatic	1.23E-03	1.82E-03	Propionaldehyde	4.37E-04	6.51E-04
C_xH_y chloro	2.06E-04	3.06E-04	Sb	4.06E-06	6.04E-06
Dichloromethane	1.50E-05	2.23E-05	Se	2.95E-05	4.38E-05
Dioxin (TEQ)	1.97E-11	2.93E-11	SO_2	1.77E-01	2.63E-01
Dust	8.04E-02	1.20E-01	SO_x	7.01E+00	1.04E+01
F_2	4.65E-08	6.92E-08	Tetrachloroethene	3.60E-06	5.36E-06
Fe	5.50E-04	8.18E-04	Tetrachloromethane	9.06E-06	1.35E-05
Formaldehyde	1.80E-01	2.68E-01	THC as Carbon	1.27E-01	1.88E-01
H_2	3.05E-02	4.54E-02	Trichloroethene	3.52E-06	5.24E-06
H_2S	8.78E-06	1.31E-05	Vinyl chloride	4.39E-10	6.54E-10
H_2SO4	2.70E-04	4.01E-04	VOC	2.22E+00	3.30E+00
HCl	2.10E-02	3.12E-02	Zn	5.51E-04	8.20E-04
HCN	9.69E-34	1.44E-33			

[1]10³m = 1.0 thousand linear meters of I-joist

Notes: Includes site generated and off-site generated emissions; these are the cumulative allocated emissions.

Table 1.15. Total allocated air emission summaries for 1.0 MLF of composite I-joists produced in the Southeast region.

Air Emissions	I-joists lb/MLF	I-joists $kg/10^3m$	Air Emission	I-joists lb/MLF	I-joists $kg/10^3m$
1,2-dichloroethane	3.01E-10	4.48E-10	HCN	6.60E-34	9.82E-34
Acetaldehyde	1.10E-01	1.63E-01	HF	5.46E-03	8.13E-03
Acetone	3.26E-02	4.85E-02	Hg	2.18E-05	3.24E-05
Acrolein	3.89E-02	5.78E-02	K	1.79E-01	2.67E-01
Aldehydes	6.20E-03	9.23E-03	Kerosene	2.40E-04	3.58E-04
Ammonia	4.15E-03	6.18E-03	MDI (isocyanate)	1.32E-04	1.96E-04
As	4.71E-05	7.00E-05	Mercaptans	8.41E-07	1.25E-06
Ash	1.48E-04	2.19E-04	Metals	2.21E-04	3.29E-04
Ba	1.01E-03	1.50E-03	Methane	2.60E+00	3.86E+00
Be	2.55E-06	3.80E-06	Methanol	4.65E-01	6.92E-01
Benzene	8.78E-04	1.31E-03	Mn	2.12E-03	3.16E-03
Cd	1.99E-05	2.96E-05	N-nitrodimethylamine	7.74E-03	1.15E-02
CFC (soft)	3.35E-05	4.98E-05	N_2O	4.54E-03	6.76E-03
Cl_2	1.81E-03	2.70E-03	Na	4.13E-03	6.15E-03
CO	6.82E+00	1.02E+01	Naphthalene	5.52E-04	8.21E-04
CO_2	4.97E+01	7.40E+01	Ni	4.03E-04	5.99E-04
CO_2 (biomass)	1.11E+03	1.66E+03	Non methane VOC	2.94E+00	4.37E+00
CO_2 (fossil)	9.51E+02	1.42E+03	NO_x	6.01E+00	8.94E+00
CO_2 (non-fossil)	6.21E+01	9.24E+01	Organic substances	4.59E-02	6.84E-02
Cobalt	2.26E-05	3.36E-05	Particulates	6.90E-01	1.03E+00
Cr	4.38E-05	6.52E-05	Particulates (PM10)	1.36E+00	2.03E+00
CS_2	2.88E-09	4.29E-09	Particulates (unspfd)	5.52E-01	8.22E-01
Cumene	3.66E-04	5.44E-04	Pb	3.09E-04	4.60E-04
C_xH_y	4.62E-02	6.87E-02	Phenol	1.36E-01	2.03E-01
C_xH_y aromatic	8.41E-04	1.25E-03	Sb	8.85E-06	1.32E-05
C_xH_y chloro	1.41E-04	2.10E-04	Se	6.14E-05	9.13E-05
Dichloromethane	3.13E-05	4.65E-05	SO_2	1.98E-01	2.95E-01
Dioxin (TEQ)	4.10E-11	6.10E-11	SO_x	1.08E+01	1.61E+01
Dust	5.48E-02	8.15E-02	Tetrachloroethene	7.52E-06	1.12E-05
F_2	3.18E-08	4.73E-08	Tetrachloromethane	2.04E-05	3.03E-05
Fe	1.01E-03	1.50E-03	Trichloroethene	7.33E-06	1.09E-05
Formaldehyde	1.85E-01	2.75E-01	Vinyl chloride	3.00E-10	4.47E-10
H_2	2.09E-02	3.11E-02	VOC	1.90E+00	2.82E+00
H_2S	5.98E-06	8.90E-06	Water vapor	6.49E+02	9.66E+02
H_2SO_4	1.84E-04	2.74E-04	Zn	1.01E-03	1.51E-03
HCl	4.04E-02	6.01E-02			

Notes: Includes site generated and off-site generated emissions; these are the cumulative allocated emissions.

1.7 LIFE-CYCLE INVENTORY RESULTS

Life-cycle inventory inputs for 1.0 MLF of composite I-joists from the PNW and SE regions are given in Tables 1.16 and 1.17. Life cycle inventory results include all processes within the system boundary as defined in Figure 1.2. The results of the LCI were generated in SimaPro 5 version 5.0.9 Life-Cycle Assessment software with the Franklin Associates' database for fuel use and electricity burdens for their production. Emissions for the production of PF resin were obtained from ATHENA™ and for MDI results were obtained from industry database in SimaPro with Boustead Consulting listed as the data collector (Pré Consultants 2001). Other inputs and outputs were obtained from the Southeast OSB (Kline 2004) and Pacific Northwest and Southeast LVL models (Wilson and Dancer 2004) as well as from surveys conducted of manufacturers. The breakdown of the fuel sources to generate I-joist in the Pacific Northwest and Southeast regions are the same as those given in Module D Softwood Plywood (Wilson and Sakimoto 2004).

Table 1.16. Life Cycle Inventory inputs for producing 1.0 MLF ofI-joists in the Pacific Northwest region.

PNW I-joist –INPUTS		
Material	**lb/MLF**	**kg/10^{3}m**
MDI (isocyanate) Resin	1.22E+01	1.82E+01
Purchased	**lb/MLF**	**kg/10^{3}m**
Laminated Veneer Lumber	1.13E+03	1.69E+03
Oriented Strand Board	1.10E+03	1.64E+03
I-joist Production, PNW		
Electrical Use	**kWh/MLF**	**kWh/10^{3}m**
Electricity	8.41E+01	9.94E+02
Fuel Use	**Btu/MLF**	**MJ/10^{3}m**
Liquid propane gas	1.51E+04	5.22E+01
Natural gas	5.02E+03	1.74E+01
Diesel	1.14E+04	3.95E+01
Water Usage	**lb/MLF**	**kg/10^{3}m**
Municipal Water Source	1.42E+02	2.11E+02
MDI (isocyanate) Resin Production		
Energy Use	**Btu/MLF**	**MJ/10^{3}m**
Energy from coal	4.74E+04	1.64E+02
Energy from oil	1.27E+05	4.38E+02
Energy from natural gas	3.04E+05	1.05E+03
Energy from hydro power	2.69E+03	9.29E+00
Energy from uranium	2.90E+04	1.00E+02
Energy from lignite	8.10E+03	2.80E+01
Energy from biomass	2.11E+02	7.29E-01
Energy from hydrogen	5.10E+03	1.77E+01
Energy (undefined)	5.26E+02	1.82E+00
Energy from peat	1.58E+01	5.46E-02
Energy from sulphur	2.26E+02	7.83E-01
Energy from wood	1.89E+01	6.55E-02
Energy recovered	-2.44E+04	-8.43E+01

Notes: Inputs include only the materials, energy, fuel and electricity that are used on-site to manufacture the I-joists.

Table 1.17. Life Cycle Inventory Inputs for producing 1.0 MLF of I-joists in the Southeast region.

SE I-joist –INPUTS		
Material	**lb/MLF**	**kg/10^{3}m**
MDI (isocyanate) Resin	5.20E+00	7.74E+00
PRF Resin	3.05E+00	4.54E+00
Purchased	**lb/MLF**	**kg/10^{3}m**
Laminated Veneer Lumber	1.61E+03	2.39E+03
Oriented Strand Board	1.19E+03	1.78E+03
I-joist Production, SE		
Electrical Use	**kWh/MLF**	**kWh/10^{3}m**
Electricity	7.51E+01	8.87E+02
Fuel Use	**Btu/MLF**	**MJ/10^{3}m**
Liquid propane gas	3.44E+04	1.19E+02
Natural gas	6.50E+04	2.25E+02
Diesel	4.14E+04	1.43E+02
Water Usage	**lb/MLF**	**kg/10^{3}m**
Municipal Water Source	4.31E+02	6.41E+02
Recycled Water	1.92E+01	2.85E+01
Well Water Source	2.83E+01	4.22E+01
PF (PRF) Resin Production		
Electrical Use	**kWh/MLF**	**MJ/10^{3}m**
Electricity	1.96E+00	2.31E+01
Fuel Use	**Btu/MLF**	**MJ/10^{3}m**
Heavy oil	1.90E+03	6.59E+00
Natural gas	1.31E+01	4.54E-02
Diesel	3.53E+04	1.22E+02
MDI (isocyanate) Resin Production		
Energy Use	**Btu/MLF**	**MJ/10^{3}m**
Energy from coal	2.01E+04	6.97E+01
Energy from oil	5.39E+04	1.86E+02
Energy from natural gas	1.29E+05	4.48E+02
Energy from hydro power	1.14E+03	3.95E+00
Energy from uranium	1.23E+04	4.27E+01
Energy from lignite	3.45E+03	1.19E+01
Energy from biomass	8.96E+01	3.10E-01
Energy from hydrogen	2.17E+03	7.51E+00
Energy (undef.)	2.24E+02	7.75E-01
Energy from peat	6.71E+00	2.32E-02
Energy from sulphur	9.62E+01	3.33E-01
Energy from wood	8.05E+00	2.79E-02
Energy recovered	-1.04E+04	-3.58E+01

Notes: Inputs include only the materials, energy, fuel and electricity that are used on-site to manufacture the I-joists.

The following Tables 1.18 and 1.19 list the life cycle outputs for manufacturing 1.0 MLF of composite I-joists in each production region.

Table 1.18. Life Cycle Inventory outputs from producing 1.0 MLF of I-joists in the Pacific Northwest region.

Product	lb/MLF	kg/10^{3}m	Other Raw Materials	lb/MLF	kg/10^{3}m
Composite I-joists	2.02E+03	3.01E+03	KCl	2.18E-01	3.25E-01
			Lead (in ore)	3.09E-05	4.60E-05
Co-products	**lb/MLF**	**kg/10^{3}m**	Limestone	7.35E+00	1.09E+01
Sawdust	2.30E+02	3.42E+02	NaCl	7.98E+00	1.19E+01
			Natural gas FAL	1.50E+02	2.24E+02
Raw Materials	**lb/MLF**	**kg/10^{3}m**	Nickel (in ore)	**1.86E-06**	2.77E-06
PNW Bark on Logs (for LVL)	4.59E+01	6.90E+01	Nitrogen	2.15E+00	3.20E+00
PNW Logs (for LVL)	9.12E+02	1.36E+03	Olivine	1.01E-04	1.50E-04
SE Bark (for OSB)	9.92E+01	1.48E+02	Oxygen	2.54E+00	3.78E+00
SE Hardwood Logs (for OSB)	3.13E+02	4.66E+02	Phosphate (as P_2O_5)	1.22E-04	1.82E-04
SE Softwood Logs (for OSB)	9.35E+02	1.39E+03	Rutile	2.83E-28	4.21E-28
			Sand	1.39E-02	2.07E-02
Other Raw Materials	**lb/MLF**	**kg/10^{3}m**	Shale	4.72E-04	7.02E-04
Air	7.13E+00	1.06E+01	Sulphur (bonded)		
Baryte	3.09E-03	4.60E-03	Sulphur (elemental)	8.32E-02	1.24E-01
Bauxite	3.64E-03	5.42E-03	Uranium FAL	5.27E-04	7.84E-04
Bentonite	1.68E-03	2.49E-03	Water	7.70E+01	1.15E+02
Calcium sulphate	1.66E-04	2.48E-04	Water (cooling)	3.03E+02	4.50E+02
Chalk	1.97E-28	2.93E-28	Water (drkng, for process.)	1.39E+03	2.07E+03
Chromium (in ore)	1.19E-11	1.76E-11	Water (process)	1.02E+01	1.52E+01
Clay minerals	1.86E-04	2.77E-04	Water (sea, for cooling)	1.76E+03	2.61E+03
Coal FAL	1.04E+02	1.54E+02	Water (sea, for processing)	6.27E+00	9.33E+00
Crude oil FAL	7.01E+01	1.04E+02	Water (surface, for cooling)	2.62E+03	3.90E+03
Dolomite	7.35E-04	1.09E-03	Water (surface, for process.)	1.88E+01	2.80E+01
Feldspar	2.49E-34	3.71E-34	Water (well, for cooling)	8.32E-02	1.24E-01
Ferromanganese	1.01E-05	1.50E-05	Water (well, for processing)	6.10E-01	9.08E-01
Fluorspar	5.45E-05	8.12E-05	Wood/wood wastes FAL	1.78E+01	2.65E+01
Granite	4.05E-07	6.03E-07	Zinc (in ore)	9.69E-07	1.44E-06
Gravel	3.77E-05	5.61E-05			
Iron (in ore)	1.18E-02	1.76E-02			

Energy from Raw Materials	Btu/MLF	$MJ/10^3m$
Heat from DFO	8.03E+03	2.78E+01
Heat from natural gas	2.03E+04	7.04E+01
Hogged Fuel Direct Fired	1.92E+06	6.63E+03
Electricity	**Btu/MLF**	**$MJ/10^3m$**
Electricity	6.08E+01	2.11E-01
Electricity from other Sources	2.77E+04	9.59E+01
Energy (undefined.)	7.26E+02	2.51E+00
Energy from biomass	2.77E+02	9.59E-01
Energy from coal	6.55E+04	2.27E+02
Energy from hydro power	5.86E+05	2.03E+03
Energy from hydrogen	7.05E+03	2.44E+01
Energy from lignite	1.12E+04	3.88E+01
Energy from natural gas	4.20E+05	1.45E+03
Energy from oil	1.75E+05	6.06E+02
Energy from peat	2.38E+01	8.24E-02
Energy from sulphur	3.30E+02	1.14E+00
Energy from uranium	4.01E+04	1.39E+02
Energy from wood	2.64E+01	9.12E-02
Energy recovered	-3.37E+04	-1.16E+02
Water Usage at Manufacturing Facility	**lb/MLF**	**$kg/10^3m$**
Municipal Water Source	5.50E+02	8.18E+02
Recycled Water	1.42E+00	2.11E+00
Well Water Source	1.26E+02	1.88E+02

Air Emissions	lb/MLF	kg/10^{3}m	Air Emissions	lb/MLF	kg/10^{3}m
1,2-dichloroethane	4.41E-10	6.56E-10	C_xH_y	6.73E-02	1.00E-01
Acetaldehyde	1.08E-01	1.61E-01	C_xH_y aromatic	1.23E-03	1.82E-03
Acetone	1.12E-02	1.67E-02	C_xH_y chloro	2.06E-04	3.06E-04
Acrolein	3.45E-02	5.13E-02	Dichloromethane	1.50E-05	2.23E-05
Aldehydes	4.54E-03	6.76E-03	Dioxin (TEQ)	1.97E-11	2.93E-11
Alpha-pinene	5.87E-02	8.74E-02	Dust	8.04E-02	1.20E-01
Ammonia	3.19E-03	4.74E-03	F_2	4.65E-08	6.92E-08
As	2.37E-05	3.53E-05	Fe	5.50E-04	8.18E-04
Ash	1.31E-04	1.95E-04	Formaldehyde	1.80E-01	2.68E-01
Ba	5.50E-04	8.18E-04	H_2	3.05E-02	4.54E-02
Be	1.20E-06	1.79E-06	H_2S	8.78E-06	1.31E-05
Benzene	4.94E-04	7.35E-04	H_2SO_4	2.70E-04	4.01E-04
Beta-pinene	2.29E-02	3.40E-02	HCl	2.10E-02	3.12E-02
Cd	9.06E-06	1.35E-05	HCN	9.69E-34	1.44E-33
CFC (soft)	4.90E-05	7.29E-05	HF	2.69E-03	4.00E-03
Cl_2	9.98E-04	1.48E-03	Hg	1.50E-05	2.23E-05
CO	4.68E+00	6.96E+00	K	9.75E-02	1.45E-01
CO_2	6.67E+01	9.92E+01	Kerosene	1.16E-04	1.73E-04
CO_2 (biomass)	8.66E+02	1.29E+03	Limonene	6.61E-03	9.84E-03
CO_2 (fossil)	5.61E+02	8.35E+02	MDI (isocyanate)	1.17E-04	1.75E-04
CO_2 (non-fossil)	1.86E+01	2.77E+01	Mercaptans	1.23E-06	1.83E-06
Cobalt	1.04E-05	1.54E-05	Metals	2.00E-04	2.97E-04
Cr	2.15E-05	3.21E-05	Methyl i-butyl ketone	4.27E-04	6.35E-04
CS_2	4.22E-09	6.28E-09	Mn	1.16E-03	1.72E-03
Cumene	3.36E-04	5.00E-04	N-nitrodimethylamine	6.84E-03	1.02E-02

Air Emissions	lb/MLF	kg/10^3m
Methane	1.77E+00	2.63E+00
Methanol	4.33E-01	6.44E-01
Methyl ethyl ketone	5.23E-04	7.79E-04
N_2O	2.17E-03	3.23E-03
Na	2.25E-03	3.35E-03
Naphthalene	3.01E-04	4.48E-04
Ni	1.94E-04	2.88E-04
Non methane VOC	2.21E+00	3.28E+00
NO_x	4.11E+00	6.12E+00
Organic substances	2.68E-02	3.99E-02
Particulates	8.49E-01	1.26E+00
Particulates (PM10)	2.81E-01	4.18E-01
Particulates (unspecified)	2.67E-01	3.97E-01
Pb	1.67E-04	2.49E-04
Phenol	1.24E-01	1.85E-01
Propionaldehyde	4.37E-04	6.51E-04
Sb	4.06E-06	6.04E-06
Se	2.95E-05	4.38E-05
SO_2	1.77E-01	2.63E-01
SO_x	7.01E+00	1.04E+01
Tetrachloroethene	3.60E-06	5.36E-06
Tetrachloromethane	9.06E-06	1.35E-05
THC as Carbon	1.27E-01	1.88E-01
Trichloroethene	3.52E-06	5.24E-06

Air Emissions	lb/MLF	kg/10^3m
Vinyl chloride	4.39E-10	6.54E-10
VOC	2.21E+00	3.29E+00
Zn	5.51E-04	8.20E-04

Water Emissions	lb/MLF	kg/10^3m
Acid as H+	1.07E-03	1.59E-03
Al	1.43E-04	2.12E-04
As	4.74E-09	7.05E-09
B	1.03E-02	1.54E-02
BOD	2.18E-02	3.25E-02
Ca	4.86E-07	7.23E-07
Calcium ions	2.01E-03	2.99E-03
Carbonate	2.50E-03	3.71E-03
Cd	3.64E-04	5.41E-04
Chromate	7.01E-06	1.04E-05
Cl-	2.78E+00	4.13E+00
Cl_2	1.89E-04	2.82E-04
COD	1.63E-01	2.43E-01
Cr	3.64E-04	5.41E-04
Cu	2.74E-06	4.07E-06
C_xH_y	6.61E-04	9.84E-04
C_xH_y chloro	5.58E-05	8.30E-05
Cyanide	7.75E-07	1.15E-06
Detergent/oil	6.56E-04	9.75E-04

Water Emissions	lb/MLF	kg/10^3m
Dissolved organics	5.81E-03	8.65E-03
Dissolved solids	8.09E+00	1.20E+01
Fe	1.45E-02	2.16E-02
Fluoride ions	4.62E-04	6.88E-04
H_2SO_4	2.58E-03	3.83E-03
Hg	5.47E-06	8.14E-06
K	6.27E-03	9.33E-03
Metallic ions	5.23E-03	7.79E-03
Mg	2.48E-04	3.69E-04
Mn	8.15E-03	1.21E-02
N-tot	1.07E-03	1.59E-03
Na	1.62E+00	2.42E+00
NH_3	3.22E-04	4.79E-04
NH_4+	3.47E-03	5.16E-03
Ni	1.29E-04	1.93E-04
Nitrate	2.64E-03	3.94E-03
Oil	1.43E-01	2.12E-01
Other organics	2.75E-02	4.09E-02
P_2O_5	1.60E-04	2.37E-04
Pb	1.16E-07	1.73E-07
Phenol	8.61E-05	1.28E-04
Phosphate	1.29E-03	1.92E-03
Sulphate	4.46E-01	6.63E-01
Sulphur/sulphide	1.18E-05	1.76E-05
Suspended solids	2.54E-01	3.78E-01
Vinyl chloride	3.68E-31	5.48E-31
Zn	9.98E-04	1.48E-03

Solid Waste Emission	lb/MLF	kg/10^3m
Boiler ash	3.10E+00	4.61E+00
Chemical waste (inert)	4.81E-02	7.16E-02
Chemical waste (regulated)	7.87E-02	1.17E-01
Construction waste	1.33E-03	1.98E-03
Industrial waste	1.78E-01	2.65E-01
Metal scrap	2.50E-04	3.72E-04
Mineral waste	1.42E+00	2.11E+00
Paper/board packaging	8.27E-05	1.23E-04
Plastics packaging	2.75E-03	4.09E-03
Slags/ash	3.51E-01	5.22E-01
Solid waste	7.24E+01	1.08E+02
Special waste	3.97E-03	5.90E-03
Unspecified	2.01E-04	2.99E-04
Waste in incineration	2.82E-02	4.19E-02
Waste to recycling	6.21E-03	9.24E-03
Wood packaging	1.35E-04	2.00E-04
Wood waste	3.35E-01	4.98E-01

Nonmaterial Emission	bq/MLF	bq/10^3m
Radioactive substance to air	3.03E+06	4.51E+06

Notes: Included in the data are site generated emissions as well as emissions from LVL, OSB and inputs of fuel, electricity, and resin. All weights are given as oven-dry and solids weights. MDI emissions as a result of I-joists production were not provided by the plants surveyed.

Table 1.19. Life Cycle Inventory outputs from producing 1.0 MLF of I-joists in the Southeast region.

Product	lb/MLF	kg/10^{3}m
Composite I-joists	2.60E+03	3.88E+03

Co-products	lb/MLF	kg/10^{3}m
Sawdust	1.96E+02	2.91E+02

Raw Materials	lb/MLF	kg/10^{3}m
SE Bark on Logs (for veneer/LVL)	6.80E+01	1.02E+02
SE Logs (for veneer/LVL)	1.36E+03	2.03E+03
SE Bark (for OSB)	1.11E+02	1.66E+02
SE Hardwood Logs (for OSB)	3.52E+02	5.23E+02
SE Softwood Logs (for OSB)	1.05E+03	1.57E+03

Other Raw Materials	lb/MLF	kg/10^{3}m
Air	4.87E+00	7.24E+00
Baryte	2.11E-03	3.14E-03
Bauxite	2.49E-03	3.71E-03
Bentonite	1.14E-03	1.70E-03
Calcium sulphate	1.14E-04	1.69E-04
Chalk	1.34E-28	2.00E-28
Chromium (in ore)	8.11E-12	1.21E-11
Clay minerals	1.27E-04	1.89E-04
Coal FAL	2.16E+02	3.22E+02
Crude oil FAL	8.78E+01	1.31E+02
Dolomite	5.01E-04	7.45E-04
Feldspar	1.70E-34	2.53E-34
Ferromanganese	6.88E-06	1.02E-05
Fluorspar	3.73E-05	5.55E-05
Granite	2.77E-07	4.12E-07
Gravel	2.57E-05	3.83E-05
Iron (in ore)	8.04E-03	1.20E-02
KCl	1.49E-01	2.22E-01
Lead (in ore)	2.11E-05	3.14E-05

Other Raw Materials	lb/MLF	kg/10^{3}m
Sulphur (bonded)	2.82E-02	4.20E-02
Sulphur (elemental)	5.68E-02	8.45E-02
Uranium FAL	1.09E-03	1.62E-03
Water	8.70E+01	1.29E+02
Water (cooling)	2.07E+02	3.08E+02
Water (drinking, for process.)	9.51E+02	1.42E+03
Water (process)	6.95E+00	1.03E+01
Water (sea, for cooling)	1.20E+03	1.79E+03
Water (sea, for processing)	4.30E+00	6.40E+00
Water (surface, for cooling)	1.79E+03	2.67E+03
Water (surface, for process.)	1.28E+01	1.91E+01
Water (well, for cooling)	5.69E-02	8.46E-02
Water (well, for processing)	4.17E-01	6.20E-01
Wood/wood wastes FAL	5.94E+01	8.83E+01
Zinc (in ore)	6.61E-07	9.83E-07

Energy From Raw Materials	Btu/MLF	MJ/10^{3}m
Heat from DFO	9.04E+03	3.13E+01
Heat from natural gas	2.29E+04	7.92E+01
Hogged Fuel Direct Fired	2.08E+06	7.19E+03

Electricity	Btu/MLF	MJ/10^{3}m
Electricity	6.86E+01	2.37E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity from other Sources	5.04E+04	1.74E+02
Energy (undefined)	4.97E+02	1.72E+00
Energy from biomass	1.90E+02	6.57E-01

Limestone	1.61E+01	2.39E+01	Energy from coal	4.47E+04	1.55E+02
NaCl	5.46E+00	8.12E+00	Energy from hydro power	2.87E+04	9.92E+01
Natural gas FAL	2.12E+02	3.16E+02	Energy from hydrogen	4.81E+03	1.67E+01
Nickel (in ore)	1.27E-06	1.89E-06	Energy from lignite	7.67E+03	2.65E+01
Nitrogen	1.47E+00	2.18E+00	Energy from natural gas	2.88E+05	9.96E+02
Olivine	6.90E-05	1.03E-04	Energy from oil	1.19E+05	4.12E+02
Oxygen	1.74E+00	2.59E+00	Energy from peat	1.63E+01	5.64E-02
Phosphate (as P_2O_5)	8.33E-05	1.24E-04	Energy from sulphur	2.25E+02	7.80E-01
Rutile	1.93E-28	2.88E-28	Energy from uranium	2.74E+04	9.47E+01
Sand	9.51E-03	1.42E-02	Energy from wood	1.81E+01	6.25E-02
Shale	3.22E-04	4.80E-04	Energy recovered	-2.30E+04	-7.96E+01

Water Usage-- at Manufacturing Facility	lb/MLF	kg/10^3m
Municipal Water Source	6.39E+02	9.50E+02
Recycled Water	2.56E+01	3.80E+01
Well Water Source	5.45E+02	8.11E+02

Air Emissions	lb/MLF	kg/10^3m
1,2-dichloroethane	3.01E-10	4.48E-10
Acetaldehyde	1.09E-01	1.62E-01
Acetone	3.26E-02	4.85E-02
Acrolein	3.89E-02	5.78E-02
Aldehydes	6.20E-03	9.23E-03
Ammonia	4.15E-03	6.18E-03
As	4.71E-05	7.00E-05
Ash	1.48E-04	2.19E-04
Ba	1.01E-03	1.50E-03
Be	2.55E-06	3.80E-06
Benzene	8.78E-04	1.31E-03
Cd	1.99E-05	2.96E-05
CFC (soft)	3.35E-05	4.98E-05
Cl_2	1.81E-03	2.70E-03
CO	6.82E+00	1.02E+01
CO_2	4.97E+01	7.40E+01
CO_2 (biomass)	1.11E+03	1.66E+03
CO_2 (fossil)	9.51E+02	1.42E+03
CO_2 (non-fossil)	6.21E+01	9.24E+01
Cobalt	2.26E-05	3.36E-05
Cr	4.38E-05	6.52E-05
CS_2	2.88E-09	4.29E-09
Cumene	3.66E-04	5.44E-04
C_xH_y	4.62E-02	6.87E-02
C_xH_y aromatic	8.41E-04	1.25E-03
C_xH_y chloro	1.41E-04	2.10E-04
Dichloromethane	3.13E-05	4.65E-05
Dioxin (TEQ)	4.10E-11	6.10E-11

Air Emissions	lb/MLF	kg/10^3m
MDI (isocyanate)	1.32E-04	1.96E-04
Mercaptans	8.41E-07	1.25E-06
Metals	2.21E-04	3.29E-04
Methane	2.60E+00	3.86E+00
Methanol	4.65E-01	6.92E-01
Mn	2.12E-03	3.16E-03
N-nitrodimethylamine	7.74E-03	1.15E-02
N_2O	4.54E-03	6.76E-03
Na	4.13E-03	6.15E-03
Naphthalene	5.52E-04	8.21E-04
Ni	4.03E-04	5.99E-04
Non methane VOC	2.94E+00	4.37E+00
NO_x	6.01E+00	8.94E+00
Organic substances	4.59E-02	6.84E-02
Particulates	6.90E-01	1.03E+00
Particulates (PM10)	1.36E+00	2.03E+00
Particulates (unspecified)	5.52E-01	8.22E-01
Pb	3.09E-04	4.60E-04
phenol	1.36E-01	2.03E-01
Sb	8.85E-06	1.32E-05
Se	6.14E-05	9.13E-05
SO_2	1.98E-01	2.95E-01
SO_x	1.08E+01	1.61E+01
Tetrachloroethene	7.52E-06	1.12E-05
Tetrachloromethane	2.04E-05	3.03E-05
Trichloroethene	7.33E-06	1.09E-05
Vinyl chloride	3.00E-10	4.47E-10
VOC	1.90E+00	2.82E+00
Water vapor	6.49E+02	9.66E+02
Zn	1.01E-03	1.50E-03

Dust	5.48E-02	8.15E-02
F_2	3.18E-08	4.73E-08
Fe	1.01E-03	1.50E-03
Formaldehyde	1.85E-01	2.75E-01
H_2	2.09E-02	3.11E-02
H_2S	5.98E-06	8.90E-06
H_2SO_4	1.84E-04	2.74E-04
HCl	4.04E-02	6.01E-02
HCN	6.60E-34	9.82E-34
HF	5.46E-03	8.13E-03
Hg	2.18E-05	3.24E-05
K	1.79E-01	2.67E-01
Kerosene	2.40E-04	3.58E-04

Water Emissions	**lb/MLF**	**kg/10^3m**
Acid as H+	8.85E-04	1.32E-03
Al	9.74E-05	1.45E-04
As	3.24E-09	4.82E-09
B	2.16E-02	3.22E-02
BOD	2.07E-02	3.07E-02
Ca	5.29E-07	7.87E-07
Calcium ions	1.51E-03	2.25E-03
Carbonate	1.70E-03	2.53E-03
Cd	5.13E-04	7.63E-04
Chromate	1.56E-05	2.32E-05
Cl-	2.16E+00	3.22E+00
Cl_2	1.29E-04	1.92E-04
COD	1.66E-01	2.47E-01
Cr	5.13E-04	7.63E-04
Cu	1.87E-06	2.78E-06
C_xH_y	4.51E-04	6.72E-04
C_xH_y chloro	3.81E-05	5.67E-05
Cyanide	9.22E-07	1.37E-06
Detergent/oil	4.49E-04	6.68E-04
Dissolved organics	4.07E-03	6.06E-03
Dissolved solids	1.14E+01	1.69E+01

Solid Waste Emission	**lb/MLF**	**kg/10^3m**
Boiler ash	3.49E+00	5.19E+00
Chemical waste (inert)	3.29E-02	4.89E-02
Chemical waste (regulated)	5.40E-02	8.03E-02
Construction waste	9.07E-04	1.35E-03
Industrial waste	1.22E-01	1.81E-01
Metal scrap	1.71E-04	2.55E-04
Mineral waste	9.74E-01	1.45E+00
Paper/board packaging	5.63E-05	8.38E-05
Plastics packaging	1.88E-03	2.80E-03
Slags/ash	2.40E-01	3.57E-01
Solid waste	1.39E+02	2.07E+02
Special waste	4.46E-03	6.64E-03
Unspecified	1.38E-04	2.05E-04
Waste in incineration	1.92E-02	2.86E-02
Waste to recycling	4.25E-03	6.32E-03
Wood packaging	9.22E-05	1.37E-04
Wood waste	3.77E-01	5.61E-01

Nonmaterial Emission	**bq/MLF**	**bq/10^3m**
Radioactive sub. to air	5.33E+06	7.94E+06

Fe	3.02E-02	4.50E-02
Fluoride ions	9.59E-04	1.43E-03
H_2SO_4	5.40E-03	8.03E-03
Hg	3.76E-06	5.60E-06
K	4.28E-03	6.36E-03
Metallic ions	4.33E-03	6.44E-03
Mg	1.70E-04	2.52E-04
Mn	1.70E-02	2.52E-02
N-tot	7.34E-04	1.09E-03
Na	1.11E+00	1.65E+00
NH_3	5.61E-04	8.34E-04
NH_4+	2.37E-03	3.52E-03
Ni	8.85E-05	1.32E-04
Nitrate	1.87E-03	2.78E-03
Oil	2.01E-01	2.98E-01
Other organics	3.81E-02	5.67E-02
P_2O_5	1.09E-04	1.62E-04
Pb	1.44E-07	2.14E-07
Phenol	6.11E-05	9.09E-05
Phosphate	2.70E-03	4.02E-03
Sulphate	5.91E-01	8.80E-01
Sulphur/sulphide	8.04E-06	1.20E-05
Suspended solids	4.41E-01	6.56E-01
Vinyl chloride	2.51E-31	3.74E-31
Zn	7.74E-04	1.15E-03

Notes: Included in the data are site generated emissions as well as emissions from LVL, OSB and inputs of fuel, electricity, and resin. All weights are given as oven-dry and solids weights. MDI emissions as a result of I-joist production were not provided by the plants surveyed.

It is also helpful to consider the emissions solely attributed to the manufacturing of composite I-joists, which is referred to as "site-generated" emissions. The following Tables 1.20, 1.21, 1.22, and 1.23 provide input and output LCI data for the I-joists excluding emissions contributed by the production of OSB, LVL, resin, fuel, and electricity. Site process related emissions are given in Tables 1.22 and 1.23. The combustion emissions that are generated on-site are still included in this analysis. The life-cycle inputs will remain virtually unchanged, however there are drastic changes that can be seen in the life-cycle outputs when the LVL, OSB, resin, fuel, and electricity burdens are removed from the system.

Table 1.20. Life-cycle Inventory inputs to produce a 1.0 MLF of composite I-joists in the Pacific Northwest.

PNW I-joist –INPUTS		
Material	**lb/MLF**	**kg/10^{3}m**
MDI (isocyanate) Resin	1.22E+01	1.82E+01
Purchased		
Laminated Veneer Lumber	1.13E+03	1.69E+03
Oriented Strand Board	1.10E+03	1.64E+03
I-joist Production, PNW		
Electrical Use	**kWh/MLF**	**MJ/10^{3}m**
Electricity	8.41E+01	9.94E+02
Fuel Use	**Btu/MLF**	**MJ/10^{3}m**
Liquid propane gas	1.51E+04	5.22E+01
Natural gas	5.02E+03	1.74E+01
Diesel	1.14E+04	3.95E+01
Water Usage	**lb/MLF**	**kg/10^{3}m**
Municipal Water Source	1.42E+02	2.11E+02
MDI (isocyanate) Resin Production		
Energy Use	**Btu/MLF**	**MJ/10^{3}m**
Energy from coal	4.74E+04	1.64E+02
Energy from oil	1.27E+05	4.38E+02
Energy from natural gas	3.04E+05	1.05E+03
Energy from hydro power	2.69E+03	9.29E+00
Energy from uranium	2.90E+04	1.00E+02
Energy from lignite	2.90E+04	2.80E+01
Energy from biomass	8.10E+02	7.29E-01
Energy from hydrogen	5.10E+03	1.77E+01
Energy (undef.)	5.26E+02	1.82E+00
Energy from peat	1.58E+01	5.46E-02
Energy from sulphur	2.26E+02	7.83E-01
Energy from wood	1.89E+01	6.55E-02
Energy recovered	-2.44E+04	-8.43E+01

Notes: Inputs include only the materials, energy, fuel and electricity that are used on-site.

Table 1.21. Life-cycle Inventory inputs to produce a 1.0 MLF of composite I-joists in the Southeast.

SE I-joist –INPUTS		
Material	**lb/MLF**	**kg/10³m**
MDI (isocyanate) Resin	5.20E+00	7.74E+00
PF (PRF) Resin	3.05E+00	4.54E+00
Purchased		
Laminated Veneer Lumber	1.61E+03	2.39E+03
Oriented Strand Board	1.19E+03	1.78E+03
I-joist Production, SE		
Electrical Use	**kWh/MLF**	**MJ/10³m**
Electricity	7.51E+01	8.87E+02
Fuel Use	**Btu/MLF**	**MJ/10³m**
Liquid propane gas	3.44E+04	1.19E+02
Natural gas	6.50E+04	2.25E+02
Diesel	4.14E+04	1.43E+02
Water Usage	**lb/MLF**	**kg/10³m**
Municipal Water Source	4.31E+02	6.41E+02
Recycled Water	1.92E+01	2.85E+01
Well Water Source	2.83E+01	4.22E+01
PF (PRF) Resin Production		
Electrical Use	**kWh/MLF**	**MJ/10³m**
Electricity	1.96E+00	2.31E+01
Fuel Use	**Btu/MLF**	**MJ/10³m**
Heavy oil	1.90E+03	6.59E+00
Natural gas	1.31E+01	4.54E-02
Diesel	3.53E+04	1.22E+02
MDI (isocyanate) Resin Production		
Energy Use	**Btu/MLF**	**MJ/10³m**
Energy from coal	2.01E+04	6.97E+01
Energy from oil	5.39E+04	1.86E+02
Energy from natural gas	1.29E+05	4.48E+02
Energy from hydro power	1.14E+03	3.95E+00
Energy from uranium	1.23E+04	4.27E+01
Energy from lignite	3.45E+03	1.19E+01
Energy from biomass	8.96E+01	3.10E-01
Energy from hydrogen	2.17E+03	7.51E+00
Energy (undefined)	2.24E+02	7.75E-01
Energy from peat	6.71E+00	2.32E-02
Energy from sulphur	9.62E+01	3.33E-01
Energy from wood	8.05E+00	2.79E-02
Energy recovered	-1.04E+04	-3.58E+01

Notes: Inputs include only the materials, energy, fuel and electricity that are used on-site.

Table 1.22. Life-cycle Inventory outputs from the production of 1.0 MLF of composite I-joists in the Pacific Northwest.

Product	**lb/MLF**	**kg/10^{3}m**	**Air Emissions**	**lb/MLF**	**kg/10^{3}m**
Composite I-joists	2.01E+03	2.99E+03	Acetone	1.26E-04	1.87E-04
			CO	1.12E-02	1.67E-02
Co-products	**lb/MLF**	**kg/10^{3}m**	CO_2 (fossil)	3.84E+00	5.72E+00
Sawdust	2.30E+02	3.42E+02	Formaldehyde	6.67E-04	9.92E-04
			Methane	1.53E-05	2.28E-05
Raw Materials	**lb/MLF**	**kg/10^{3}m**	Methanol	1.53E-02	2.27E-02
Laminated Veneer Lumber	1.02E+03	1.52E+03	Non methane VOC	1.21E-02	1.80E-02
Oriented Strand Board	9.92E+02	1.48E+03	NO_x	5.99E-02	8.91E-02
MDI (isocyanate) Resin	1.10E+01	1.64E+01	Particulates	2.54E-03	3.78E-03
			SO_x	2.58E-03	3.83E-03
Other Raw Materials	**ft^3/MLF**	**m^3/10^{3}m**			
Distillate Fuel Oil (DFO)	9.60E-03	8.92E-04	**Water Emissions**	**lb/MLF**	**kg/10^{3}m**
Natural Gas Volume	1.75E+01	1.63E+00	BOD	1.23E-06	1.82E-06
			COD	1.05E-04	1.56E-04
Electricity	**Btu/MLF**	**MJ/10^{3}m**	Dissolved solids	2.06E-04	3.06E-04
Electricity from ATHENA	2.58E+05	8.93E+02	NH_3	2.37E-07	3.52E-07
			Suspended solids	2.19E-04	3.26E-04
Water Usage	**lb/MLF**	**kg/10^{3}m^3**			
Municipal Water Source	1.27E+02	1.89E+02			

Notes: Site generated emissions and do not include emissions related to the production of LVL, OSB, fuel, resin, electricity, logs and their transportation.

Table 1.23. Life-cycle Inventory outputs from the production of 1.0 MLF of composite I-joists in the Southeast.

Product	**lb/MLF**	**kg/10^3m**	**Air Emissions**	**lb/10^3m**	**kg/10^3m**
Composite I-joists	2.60E+03	3.88E+03	Acetone	1.00E-04	1.49E-04
			CO	2.54E-02	3.77E-02
Co-products	**lb/MLF**	**kg10^3m /**	CO_2 (fossil)	1.29E+01	1.93E+01
Sawdust	1.96E+02	2.91E+02	Formaldehyde	1.58E-03	2.36E-03
			Methane	2.42E-04	3.60E-04
Raw Materials	**lb/MLF**	**kg/10^3m**	Methanol	1.22E-02	1.82E-02
Laminated Veneer Lumber	1.15E+03	1.71E+03	Non methane VOC	8.49E-03	1.26E-02
Oriented Strand Board	8.55E+02	1.27E+03	NO_x	1.19E-01	1.77E-01
PF (PRF) Resin	2.19E+00	3.26E+00	Particulates	7.64E-03	1.14E-02
MDI (isocyanate) Resin	3.73E+00	5.56E+00	Particulates (PM10)	2.01E-02	2.99E-02
			SO_x	1.17E-02	1.74E-02
Other Raw Materials	**ft^3/MLF**	**$m^3/10^3$m**			
Distillate Fuel Oil (DFO)	2.78E-02	2.58E-03	**Water Emissions**	**lb/MLF**	**kg/10^3m**
Natural Gas Volume	6.91E+01	6.42E+00	BOD	1.94E-05	2.88E-05
			COD	1.66E-03	2.48E-03
Electricity	**Btu/MLF**	**MJ/10^3m**	Dissolved solids	3.25E-03	4.84E-03
Electricity from ATHENA	1.84E+05	6.38E+02	NH_3	3.74E-06	5.56E-06
			Suspended solids	3.47E-03	5.16E-03
Water Usage	**lb/MLF**	**kg/10^3m**			
Municipal Water Source	3.09E+02	4.59E+02			
Recycled Water	1.37E+01	2.04E+01			
Well Water Source	2.03E+01	3.02E+01			

Notes: Site generated emissions only; they do not include emissions related to the production of LVL, OSB, fuel, resin, electricity, logs and their transportation.

2.0 SENSITIVITY ANAYSIS

2.1 SCENARIO ANALYSES OF COMPOSITE I-JOIST MANUFACTURING

Scenario analyses are useful to determine the changes in a manufacturing system when some of the parameters or input materials are changed. For instance, there are specific fuel inputs to make electricity in each region. As a result, there are different types of emissions generated in each region in the process of making electricity. By changing the fuel inputs to make electricity it is possible to see the effects this would have on the life cycle outputs. Another type of scenario analysis is to change the input materials used to make a certain product. With composite I-joists, the most common inputs in the US are LVL as flange material and OSB as webbing. The life cycle outputs for these input materials have been listed in this report, but what if the inputs changed? A scenario analysis has been completed to show the effects of substituting solid sawn lumber for LVL and replacing OSB with plywood as a web material. This scenario is based on life cycle emissions data. The following scenarios were completed using SimaPro life cycle data.

2.1.1 Changing fuel inputs to make electricity in the Pacific Northwest and Southeast

The first scenario analysis involves changing the fuel source mix to make electricity in each region. In the Pacific Northwest, the dominant form of electricity production is hydroelectric generation. Roughly three-quarters of the power generated in the Pacific Northwest comes from hydroelectric dams. Since SimaPro does not assign burdens to the production of hydroelectricity, only one-quarter of the power generated has an environmental burden. It is possible that as a result of new policy that dams in the region could be breached, thus developing a need to rely on other sources of energy to make up for the shortfall created. One fuel source that would likely take its place is natural gas. The scenario created for the PNW shows the effects of decreasing the amount of hydroelectric power in the PNW by 10% and increasing the use of natural gas to generate electricity by 10%. Table 1.5 has the breakdown of electricity generation in the PNW by percentage of each source. If the table were to be created based on the inputs from this scenario, hydroelectric would be at 64.3% rather than 74.3% and natural gas would change from 12.3% to 22.3%.

In the Southeast, the dominant form of electricity generation comes from burning coal (45.56%). Unlike the PNW, in the SE the dominant form of electricity generation has many environmental burdens associated with it. The scenario for the SE is based on reducing the input of coal used to make electricity by 10% and increase input of natural gas by 10%. Since they are both fossil fuels, the dependence on them has not been reduced, merely shifted from one form to another. Table 1.6 has the breakdown of electricity generation in the SE by percentage of each source. If the table was to be created based on the inputs from this scenario, coal would be at 35.56% rather than 45.56% and natural gas would change from 23.03% to 33.03%. The emissions are total emissions (site and off-site generated) yet the change in electricity is for the I-joist production facility only. This results in small overall changes in total emissions given that the majority of emissions come from off-site sources. Tables 2.1 and 2.2 show the effects on air emissions as a result of changing the inputs for making electricity in each region.

Table 2.1. Changes in air emissions due to changing the electricity generation profile in the Pacific Northwest as a result of reducing hydroelectricity generation by 10% and replacing with natural gas generated electricity.

Air Emission	Total Allocated Emissions for I-joists with Current Fuel Sources for Electricity Generation lb/MLF	Emissions Increase or Decrease with Change in Electricity Source %/MLF	Total Allocated Emissions for I-joists with Hydroelectric Reduced 10% and Nat. Gas Increased 10% lb/MLF
CO_2 (biomass)	8.66E+02	0.0	8.66E+02
CO_2 (fossil)	5.61E+02	2.5	5.76E+02
CO_2 (non-fossil)	1.86E+01	0.0	1.86E+01
Methane	1.77E+00	1.9	1.80E+00
NO_x	4.11E+00	1.0	4.15E+00
SO_2	1.77E-01	0.0	1.77E-01
SO_x	7.01E+00	2.4	7.18E+00
Acetaldehyde	1.08E-01	0.0	1.08E-01
Acrolien	3.45E-02	0.0	3.45E-02
Formaldehyde	1.80E-01	0.0	1.80E-01
Methanol	4.33E-01	0.0	4.33E-01
Phenol	1.24E-01	0.0	1.24E-01
CO	4.68E+00	0.5	4.70E+00
Particulates	8.49E-01	0.0	8.49E-01
Particulates (PM10)	2.81E-01	0.0	2.81E-01
Particulates (Unspec.)	2.67E-01	0.2	2.67E-01
Non Methane VOC	2.21E+00	2.1	2.25E+00
VOC	2.22E+00	0.0	2.22E+00

Data from SimaPro 5.0 LCI Analysis

Full LCI listing in Appendix A2.3

Notes: These are the cumulative allocated emissions for site and off-site, also referred to as total emissions do not include transportation or log impacts.

Table 2.2. Changes in air emissions due to changing the electricity generation profile in the Southeast as a result of decreasing coal generated electricity by 10% and increase natural gas generated electricity by 10%.

Air Emission	Total Allocated Emissions for I-joist with Current Fuel Sources for Electricity Generation lb/MCF	Emissions Increase or Decrease with Change in Electricity Source %/MLF	Total Allocated Emissions for I-joists with Coal Reduced 10% and Nat Gas Increased 10% lb/MCF
CO_2 (biomass)	1.11E+03	0.0	1.11E+03
CO_2 (fossil)	9.51E+02	-0.8	9.44E+02
CO_2 (non-fossil)	6.21E+01	0.0	6.21E+01
Methane	2.60E+00	-0.6	2.58E+00
NO_x	6.01E+00	-0.7	5.97E+00
SO_2	1.98E-01	0.0	1.98E-01
SO_x	1.08E+01	1.4	1.10E+01
Acetaldehyde	1.10E-01	-0.3	1.09E-01
Acrolien	3.89E-02	0.0	3.89E-02
Formaldehyde	1.85E-01	0.0	1.85E-01
Methanol	4.65E-01	0.0	4.65E-01
Phenol	1.36E-01	0.0	1.36E-01
CO	6.82E+00	0.5	6.86E+00
Particulates	6.90E-01	0.0	6.90E-01
Particulates (PM10)	1.36E+00	-0.5	1.36E+00
Particulates (Unspec.)	5.52E-01	-6.9	5.14E-01
Non Methane VOC	2.94E+00	2.8	3.02E+00
VOC	1.90E+00	-0.1	1.90E+00

Data from SimaPro 5.0 LCI Analysis

Full LCI listing in Appendix A2.4

Notes: These are the cumulative allocated emissions for site and off-site, also referred to as total emissions do not include transportation or log impacts.

By switching the fuel inputs in the Pacific Northwest, there are a few slightly noticeable changes in the air emissions shown. The biggest changes are CO_2 (fossil), SO_x, and Non Methane VOC, which show over 2% increases in mass with the 10% increase in natural gas usage. One would expect only to see increases in air emission outputs with this scenario since SimaPro assigns no burdens to hydroelectric power generation. This assumption holds true as evidenced by the output table where the emissions either stay the same or increase with increased natural gas usage. One can also assume that if the percentage of natural gas use for the region increased or decreased, the general trend in emissions changes would be proportional to the sizes of the changes that have been observed in this study.

In the Southeast, there are also slightly noticeable changes in air emissions with the change in fuel source usage to generate electricity. Most of the changes in air emissions show a decrease in mass as the amount of coal is decreased and natural gas is increased. The most significant change is a 5.1% decrease in particulates (unspecified) as a result of the change. On the other hand, the SimaPro LCI data shows an increase of particulates and non-methane VOC with an increase in natural gas usage. Again it can be assumed that the changes observed in this report should remain consistent if the variations in fuel use source differ from 10%.

Again, it should be noted that the data in the fuel source scenario represents only a change in the electricity used at the I-joist manufacturing facility. As shown in previous tables, the emissions generated at the I-joist facility are relatively small compared to the emissions generated while making the input materials of LVL and OSB. If the fuel use inputs changed in the Pacific Northwest it would also affect the amount of emissions generated at the LVL plants and the plants that generated the dry veneer and PLV to make the LVL. This would dramatically affect the overall emissions since those input products contribute greatly to the finished product. In the Southeast, the input of LVL would experience the same changes along with the plants that generated the dry veneer to make the LVL. However, the Southeast would also see a change in the emissions generated in the OSB manufacturing process

2.1.2 Changes in air emissions due to switching material inputs to make I-joists

The most widely used materials for composite I-joist in the US are laminated veneer lumber (LVL) and OSB. They are not, however, the only materials that can be used to make this product. For instance, softwood lumber could serve as a replacement for LVL as flange material and softwood plywood could replace OSB in the web. This scenario shows the effects that making these changes would have on the LCI outputs as given by SimaPro. In each region, the replacement materials were products manufactured in the same region with SimaPro life cycle data generated for CORRIM. The creator of the softwood lumber LCI models for both regions is Mike Milota of Oregon State University (Milota 2004). The creators of the softwood plywood LCI models for both regions are Jim Wilson and Eric Sakimoto of Oregon State University (Wilson and Sakimoto 2004). The transportation to deliver these products to the I-joist facilities differ from those for OSB and LVL, and are not considered in this analysis. The following tables show the effects on air emissions as a result of switching material input products to make composite I-joists. Plywood replaced OSB on a volume basis and not on a weight basis whereas lumber replaced LVL in terms of the lumber necessary to replace it structurally. As a result, the lumber replacement volume is equivalent to a nominal 2x3 piece of lumber. The actual cross-section dimensions for the lumber are 1.5x2.5 inches and they are consistent for both regions. Tables 2.3 and 2.4 illustrate what happens to selected air emissions when the input materials to make I-joists in each region are changed.

Table 2.3. Changes in allocated air emissions resulting in changing the input materials to make composite I-joists in the Pacific Northwest.

Air Emission	I-joist of LVL and OSB Components lb/MLF	Increase or Decrease (-) when Changing Component Type %	I-joist of Lumber and Plywood Components lb/MLF
CO_2 (biomass)	8.66E+02	-19.4	6.98E+02
CO_2 (fossil)	5.61E+02	-44.1	3.14E+02
CO_2 (non-fossil)	1.86E+01	-12.4	1.63E+01
Methane	1.77E+00	-41.2	1.04E+00
NOx	4.11E+00	-44.3	2.29E+00
SO_2	1.77E-01	-99.6	6.86E-04
SOx	7.01E+00	-36.7	4.44E+00
Acetaldehyde	1.08E-01	-89.3	1.16E-02
Acrolien	3.45E-02	-100.0	2.85E-06
Formaldehyde	1.80E-01	-80.0	3.60E-02
Methanol	4.33E-01	-70.0	1.30E-01
Phenol	1.24E-01	-72.4	3.43E-02
CO	4.68E+00	17.0	5.48E+00
Particulates	8.49E-01	-54.6	3.86E-01
Particulates (PM10)	2.81E-01	-29.8	1.97E-01
Particulates (Unspecified)	2.67E-01	-74.3	6.86E-02
Non Methane VOC	2.21E+00	-43.1	1.25E+00
VOC	2.22E+00	-64.3	7.91E-01

Data from SimaPro 5.0 LCI Analysis

Full LCI listing in Appendix A2.1

Notes: These are the cumulative allocated emissions for site and off-site, also referred to as total emissions, they do not include transportation or log generation impacts.

Table 2.4. Changes in allocated air emissions resulting in changing the input materials to make composite I-joists in the Southeast.

Air Emission	I-joists of LVL and OSB Components lb/MLF	Increase or decrease (-) with Change in Component Types %	I-joists of Lumber and Plywood Components lb/MLF
CO_2 (biomass)	1.11E+03	3.5	1.15E+03
CO_2 (fossil)	9.51E+02	-50.4	4.72E+02
CO_2 (non-fossil)	6.21E+01	-19.7	4.99E+01
Methane	2.60E+00	-53.6	1.21E+00
NO_x	6.01E+00	-42.9	3.43E+00
SO_2	1.98E-01	-100.0	6.67E-05
SO_x	1.08E+01	-55.1	4.87E+00
Acetaldehyde	1.10E-01	-95.1	5.38E-03
Acrolien	3.89E-02	-100.0	1.01E-05
Formaldehyde	1.85E-01	-80.4	3.62E-02
Methanol	4.65E-01	-72.2	1.30E-01
Phenol	1.36E-01	-58.4	5.68E-02
CO	6.82E+00	25.9	8.59E+00
Particulates	6.90E-01	-11.4	6.11E-01
Particulates (PM10)	1.36E+00	-86.0	1.91E-01
Particulates (Unspecified)	5.52E-01	-40.7	3.28E-01
Non Methane VOC	2.94E+00	-61.3	1.14E+00
VOC	1.90E+00	-1.5	1.87E+00

Data from SimaPro 5.0 LCI Analysis
Full LCI listing in Appendix A2.2

Notes: These are the cumulative allocated emissions for site and off-site, also referred to as total emissions, they do not include transportation or log impacts.

The results of this scenario show dramatic decreases in the air emissions generated after switching input products. Every listed air emission, with the exception of CO in the SE, showed a decrease in mass due to the new input materials. This can most likely be attributed to the fact that the new input materials experience less total processing which contributes to less overall emissions. For example, softwood lumber replaces LVL as a flange material in this scenario. Softwood lumber, unlike LVL, contains no resin, does not require hot pressing, and does not have to be dried to as low of a moisture content as the veneer to make LVL. All of these factors contribute to softwood lumber having fewer emissions than LVL. Plywood and OSB are similar products with the exception that OSB uses PF and MDI (isocyanate) resins and plywood only uses only PF resin, and the OSB is generally about 30% denser. Another difference in the two products is the amount of energy associated with producing 1.0 MSF 3/8's of each product. The following Table 2.5 shows the energy inputs used for each manufacturing process.

Table 2.5. Comparison of fuel use categories between softwood plywood and OSB.

Energy Type	per MSF 3/8's		
	PNW Plywood	SE Plywood	OSB
Electricity (kWh)	1.39E+02	1.22E+02	1.83E+02
Wood fuel (lb)[1]	2.09E+02	2.70E+02	4.18E+02
Natural Gas (ft^3)	1.63E+02	2.42E+02	5.43E+02

Source: 2002 CORRIM report and modified OSB data; these are actual input weights and have not been allocated.
[1] Ovendry weight of bark; for energy calculations assumed to be at 50% moisture content wet basis.

As the previous table demonstrates, there are considerable differences in the amount of energy used to manufacture the two panel products. The fact that OSB uses much more wood fuel and natural gas as well as more electricity leads to higher levels of emissions outputs. Replacing OSB with plywood also contributes to the lower levels of emissions in the alternate material I-joists.

3.0 CARBON BALANCE FOR COMPOSITE I-JOISTS

Another analysis that was completed for this study was a biogenic carbon balance in which the element carbon was tracked in a "gate-to-gate" analysis of I-joist production (forest carbon dynamics are not included but can be found in Module A Forest Resources). Wood is considered a storage place for carbon yet tracking carbon through the manufacturing process is yet to be fully documented. In order to track carbon in the I-joist process it was necessary to determine all of the wood related input elements that contain carbon and the amount of carbon entering the I-joist system. It is important to note that only carbon in wood and the carbon containing emissions that can be attributed to wood were tracked. That number was compared to the carbon output number, which was obtained from the SimaPro LCI data.

The two wood related input elements into the I-joist system are LVL and OSB, while the outputs consist of sawdust, I-joists and those emissions related to the pressing, drying or combustion of wood. The two values should have very close agreement since the process is relatively simple in regard to tracking material flows. The carbon value for LVL in each region is calculated based on the species of wood that comprise the product. In the PNW, it was assumed that all of the LVL input veneer was made from Douglas fir. In the Southeast, the input veneer for LVL was assumed to be the same as the inputs for plywood in that region. That being the case, the two primary species that were used in the Southeast Plywood LCI are Loblolly pine and Slash pine with an equal weighting of 50% each for the input.

For the sake of simplicity the amount of carbon in each input product was assumed to be 50% (Birdsey 1992). This number should be very close to the actual value given what is known about the carbon percentage in wood. The following Tables 3.1 and 3.2 give the estimates of the amounts of carbon in the input products used to make composite I-joists in both the Pacific Northwest and Southeast regions.

Table 3.1. Wood input materials and the associated carbon for the inputs to manufacture 1.0 MLF of I-joist in the Pacific Northwest.

Input Material	Input %	Density Ovendry lb/ft^3	Weight of Wood lb	Weight of Carbon lb	Percent Carbon[1]
Laminated Veneer Lumber	5.07E+01	3.30E+01	1.12E+03	5.59E+02	~50%
Oriented Strand Board	4.93E+01	4.03E+01	1.06E+03	5.30E+02	~50%
TOTAL	1.00E+02	3.66E+01	2.18E+03	1.09E+03	~50%

[1] lb carbon/lb wood

Notes: Inputs are wood only, no resin is included.

Table 3.2. Wood input materials and the associated carbon for the inputs to manufacture 1.0 MLF of I-joist in the Southeast.

Input Material	Input %	Density Ovendry lb/ft^3	Weight of Wood lb	Weight of Carbon lb	Percent Carbon[1]
Laminated Veneer Lumber	5.78E+01	3.78E+01	1.57E+03	7.86E+02	~50%
Oriented Strand Board	4.22E+01	4.03E+01	1.15E+03	5.74E+02	~50%
TOTAL	1.00E+02	3.91E+01	2.72E+03	1.36E+03	~50%

[1] lb Carbon/lb Wood

Notes: Inputs are wood only, no resin is included.

The following is a list of inputs into the I-joist system and the results of the LCI completed for I-joist production in each region. Only the compounds containing wood are shown and it is not a complete list of all compounds involved in I-joist manufacturing. A carbon balance was completed for LVL in the PNW and SE for the CORRIM project. This information is included in the LVL report completed by Eric Dancer and Jim Wilson of Oregon State University (Wilson and Dancer 2004). To perform a carbon balance for these products in this report would be redundant. The following Tables 3.3 and 3.4 show the relatively simplistic carbon balance for composite I-joist production in each region.

Table 3.3. Carbon balance for the production of 1.0 MLF of composite I-joists in the Pacific Northwest.

INPUTS			
Material	**Material lb/MCF**	**Carbon %**	**Carbon lb/MCF**
Laminated Veneer Lumber	1.12E+03	50.00	5.59E+02
Oriented Strand Board	1.06E+03	50.00	5.30E+02
Total Carbon Inputs			**1.09E+03**
OUTPUTS			
Product	**Material lb/MCF**	**Carbon %**	**Carbon lb/MCF**
Composite I-joists	1.95E+03	50.00	9.77E+02
Co-products			
Sawdust	2.22E+02	50.00	1.11E+02
Air Emission	**Material lb/MCF**	**Carbon %**	**Carbon lb/MCF**
Formaldehyde	1.80E-04	40.00%	7.20E-05
Methanol	1.70E-02	37.50%	6.38E-03
Total Carbon Outputs			**1.09E+03**
% Difference			**5.93E-04**

Notes: Inputs and outputs represent wood only with no resin.

Table 3.4. Carbon balance for the production of 1.0 MLF of composite I-joists in the Southeast.

Materials	Material lb/MCF	Carbon %	Carbon lb/MCF
SE Inputs			
Laminated Veneer Lumber	1.57E+03	50.00	7.86E+02
Oriented Strand Board	1.15E+03	50.00	5.74E+02
Total Carbon Inputs			1.36E+03
PNW LVL Outputs			
Product	**Material lb/MCF**	**Carbon %**	**Carbon lb/MCF**
Composite I-joists	2.53E+03	50.00	1.26E+03
Co-products			
Sawdust	1.90E+02	50.00	9.52E+01
Air Emission	**Material lb/MCF**	**Carbon %**	**Carbon lb/MCF**
Particulates	2.80E-02	50.00%	1.40E-02
Formaldehyde	1.80E-04	40.00%	7.20E-05
Methanol	1.70E-02	37.50%	6.38E-03
Total Carbon in Outputs			1.36E+03
% Difference			1.50E-03

Notes: Inputs and outputs represent wood only with no resin.

4.0 COST ANALYSIS OF PACIFIC NORTHWEST AND SOUTHEAST COMPOSITE I-JOISTS

A cost analysis was completed for composite I-joist manufacturing in the Pacific Northwest and Southeast regions of the US. The analysis involved subtracting the associated production costs (fixed and variable) from the market price of I-joists to determine the profit margin before taxes.

The items included in the analysis were input material costs (LVL, OSB) as well as fuel, electricity and resin costs. Other costs include labor, overhead, capital, and maintenance costs. The last factor for consideration is the revenue generated from selling the co-product sawdust. A weighted average of production was created using the survey data obtained from the I-joist manufacturing facilities in each region. According to survey data and additional data from I-joist manufacturing personnel, the average number of employees at a typical I-joist plant was determined. The typical I-joist plant, indicted by the information received from our survey, in the PNW produces around 70,000 MLF of I-joist with about 30 employees whereas in the SE the number of employees is 47 and the average production is just under 41,000 MLF per year.

4.1 VARIABLE COST

Variable costs are those costs, which are directly affected by the amount of product being produced at the I-joist plant. Examples of variable costs are electricity, resin, natural gas and other fuels as well as the material inputs of LVL and OSB. These products often have not only variable usage levels between production facilities but also varying costs as well. For example, in the Pacific Northwest the average cost of electricity had a range of 3.60 cents per kWh to 5.90 cents per kWh. In this case and average value of 4.25 cents per kWh was used to the cost analysis. In the Southeast, the average electricity cost varied between 3.10 to 6.90 cents per kWh with an average of 4.70 cents per kWh. The electricity data comes from the year 2001 for each region. Another major variable cost is natural gas, which is used in the production of composite I-joists. The data used for this analysis comes from 1999 when the prices for natural gas were not affected by what is believed to be an abnormal spike in cost. Again, there was a range of values in each region with the PNW having a range of $2.20 to $4.70 per Dtherm, or decatherm, (1,000,000 Btu) with an average value of $2.85 per Dtherm. In the Southeast the range of natural gas prices was $2.00 to $4.90 per Dtherm with an average value of $2.60. Tables 4.1 and 4.2 display the variable costs in each region on an annual basis and on a production basis based on MLF. Table 4.3 gives a listing of the materials in the variable costs analysis and where the prices for each were acquired.

Table 4.1. Annual variable cost to produce 1.0 MLF of I-joist in the Pacific Northwest.

Variable Costs	Units	$/Unit	Yearly Basis	$/Year	Unit/MLF	$/MLF
Energy Consumption						
Electricity	kWh	0.04	5,848,125	248,545	84.14	3.58
Liquid propane gas	gal	0.95	180,712	171,677	2.60	2.47
Diesel	gal	1.26	87,576	110,083	1.26	1.58
Natural Gas	MM Btu	2.85	1,043	2,971	0.02	0.04
Input Materials						
LVL	ft^3	9.35	2,388,877	22,339,818	34.37	321.41
OSB	M 3/8	172.0	60,330	10,376,774	0.87	149.30
Resin						
MDI	lb	1.0	850,738	850,738	12.24	12.24
Total Variable Costs						**490.62**

Table 4.2. Annual variable cost to produce 1.0 MLF of I-joists in the Southeast.

Variable Cost	Unit	$/Unit	Yearly Basis	$/Year	Unit/MLF	$/MLF
Energy Consumption						
Electricity	kWh	0.047	3,064,912	144,051	75.13	3.53
Liquid propane gas	gal	0.95	142,782	135,643	3.50	3.33
Diesel	gal	1.14	110,146	125,566	2.70	3.08
Natural Gas	MM Btu	2.6	2,639	6,861	0.07	0.17
Materials						
LVL	ft^3	9.54	1,733,778	16,535,769	42.50	405.34
OSB	M 3/8	152	38,347	5,828,758	0.94	142.88
Resin						
MDI	lb	1.0	212,133	212,133	5.2	5.20
PRF	lb	1.0	124,424	124,424	3.05	3.05
Total Variable Costs						**566.57**

Table 4.3. Sources of prices for variable costs in the Pacific Northwest and Southeast.

Energy Consumption	Source
Electricity	Confidential E-mail—composite average of numerous plants
Liquid Propane Gas	Ferrell gas price quote 1-22-02
Diesel	(www.eia.doe.gov.) Diesel prices for west coast and gulf coast 3-03-02
Natural Gas	Confidential E-mail—composite average of numerous plants
Materials	
LVL	Price estimates from LVL cost analyses
OSB	Crow's Weekly Market Report of Lumber and Panels 1-17-02 for 3/8 inch OSB sheathing
Resin	
MDI	Confidential E-mail
PRF	Confidential E-mail

4.2 FIXED COSTS

The next major element in the cost analysis is fixed costs. Fixed costs are costs that remain constant even when levels of production are changed. The fixed costs that are associated with I-joist production are capital, interest on capital, maintenance, labor, and overhead costs. The following Tables 4.4 and 4.5 list the fixed costs in the Pacific Northwest and Southeast regions.

Table 4.4. Fixed costs for the production of composite I-joists in the Pacific Northwest .

Fixed Costs	$/Year	$/MLF
Capital Costs	859,500	12.37
Interest on Capital	1,375,200	19.79
Maintenance Costs	173,762	2.50
Labor Costs	2,488,200	35.80
Overhead	194,613	2.80
Total Fixed Costs		**73.25**

Table 4.5. Fixed costs for the production of composite I-joists in the Southeast.

Fixed Costs	$/Year	$/MLF
Capital Costs	865,710	21.22
Interest on Capital	1,385,136	33.95
Maintenance Costs	59,968	1.47
Labor Costs	2,126,280	52.12
Overhead	66,495	1.63
Total Fixed Costs		**110.40**

Adding the fixed and variable costs will give the total I-joist production costs in each region. In the PNW, that number is $563.87, in the SE that number is $676.97.

4.3 ENERGY AND CO-PRODUCTS SOLD

During the production of I-joists there was only one co-product, sawdust, which was reported on the survey. Since none of the surveyed plants utilized hog-fuel (wood and bark waste) to generate energy, it was assumed that the co-product was sold. The sawdust is sold on an oven-dry basis with the ton being the unit of weight. The following Tables 4.6 and 4.7 list the products that were sold outside of the plant.

Table 4.6. Co-products sold in the Pacific Northwest.

Sold Co-Products	$/lb	Yearly lb	$/Year	lb/MLF	$/MLF
Sawdust	0.015	15,958,279	239,374	229.60	3.44
Total Sold					**3.44**

Table 4.7. Co-products sold in the Southeast.

Sold Co-Products	$/lb	Yearly lb	$/Year	lb/MLF	$/MLF
Sawdust	0.015	7,975,379	119,631	195.5	2.93
Total Sold					**2.93**

The estimated selling price for wood waste is $30/ovendry ton. The prices of these materials were adjusted to a per pound basis for this analysis. Since the I-joist process is very efficient and creates little material waste, there is very little co-product to sell. The amount of money made from selling these products is small even on a 1.0 MLF basis. In the PNW this value is $3.44 per MLF and in the SE the value is $2.93 per MLF. Table 4.8 shows the fixed and variable costs as well as the co-products sold that are associated with the production of 1.0 MLF of I-joists in each region.

Table 4.8. Fixed Costs, Variable Costs, and Co-products sold associated with the production of 1.0 MLF of I-joists in the Pacific Northwest and Southeast.

Fixed Costs	**PNW $/MLF**	**SE $/MLF**
Capital Costs	12.37	21.22
Interest on Capital	19.79	33.95
Maintenance Costs	2.50	1.47
Labor Costs	35.80	52.12
Overhead	2.80	1.63
Total Fixed Costs	**73.25**	**110.40**
Variable Costs	**$/MLF**	**$/MLF**
Electricity	3.58	3.53
Liquid Propane Gas	2.47	3.33
Diesel	1.58	3.08
Natural Gas	0.04	0.17
LVL	311.83	395.42
OSB	141.83	135.74
MDI Resin	12.24	5.20
PRF Resin	0.00	3.05
Total Variable Costs	**473.57**	**549.51**
Sold Co-products		
Sawdust	3.44	2.93
Total Sold Co-products	**3.44**	**2.93**
Fixed + Variable – Sold Co-Product	**543.38**	**656.97**

5.0 SUMMARY OF FINDINGS

Composite I-joist production is very consistent in terms of both input products and other materials used. One notable exception is the additional use of PRF resin in the SE while the survey data from the PNW only had MDI (isocyanate) resin being used. One plant used a minute amount of structural lumber for flange material for producing I-joists but it was too small to consider in the analysis. The data for LVL comes from the LCI data generated for LVL in the PNW and SE regions, and OSB LCI data was obtained from the SE region only. Of the plants surveyed, they all produced LVL and I-joist at the same plant. These dual-purpose facilities are very common in the industry, but there are stand alone plants as well. The quality of the data is considered good for this type of study based on between plant comparisons, and mass and energy balances.

The production of composite I-joists contributes relatively small amounts of emissions when compared to the production of input products such as LVL, OSB, resin, veneer, fuel, and electricity. As Tables 1.10, 1.11, 1.12, and 1.13 illustrate, a large percentage of emissions attributed to the I-joist manufacturing process come from the inputs of LVL and OSB (also includes the resin used to manufacture these products). LCI results for each region that include only site-generated emissions (Tables 1.22 and 1.23) demonstrate the small amount of emissions actually attributable to the I-joist process. Given this scenario, it would make sense to look at these areas (LVL and OSB) as possible factors in reducing total emissions for the process. Changing the input components to make I-joists from LVL and OSB to structural lumber and plywood, respectively, has a major effect on reducing emissions.

The major component of variable costs in each region is the input material of both wood inputs (LVL, OSB). Labor in both regions is the highest fixed cost associated with I-joist production followed by interest on capital and capital costs. Fixed and variable costs are dependent on the size of the operation but the relationship of the various costs should stay the same.

The types of electricity generation in each region contribute small but noticeable levels of emissions to the I-joist manufacturing process when both site and off-site generated emissions are considered. Changes in the respective regions could contribute to the overall emissions levels. As was shown in Tables 2.1 and 2.2, changes in the major contributors to electricity generation leads to changes in the total emissions generated by producing LVL. In the PNW for example, reducing hydroelectric generation by 10% of the total for the region and making up the difference with natural gas would result in slight increases in CO_2 (fossil), NO_x, SO_x, methane, and non-methane VOC levels. In the SE, reducing the amount of coal as an input for electricity production by 10% and replacing it with natural gas results in decreases in several air emissions including CO_2 (fossil), methane, NO_x, and most significantly, particulates (unspecified).

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APPENDIX 1: LCI DATA FOR I-JOISTS

LCI data for the three most common dimensions of I-joists, as reported on the surveys, in each region. The LCI data is based on the estimated material input weights for the given dimensions of each of the I-joists.

Table A1.1. LCI data for 1.0 MLF of I-joists in the PNW with the dimensions of 9.5" in depth with flange dimensions of ~1.5"x 1.75".

LCI Inputs

PNW I-joist –INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per 10^3m^3**
MDI (isocyanate) Resin	lb	1.18E+01	kg	1.75E+01
Purchased				
Laminated Veneer Lumber	lb	1.05E+03	kg	1.57E+03
Oriented Strand Board	lb	1.09E+03	kg	1.61E+03
	I-joist Production, PNW			
Electrical Use				
Electricity	kWh	8.08E+01	MJ	9.55E+02
Fuel Use				
Liquid propane gas	Btu	1.74E+03	MJ	6.02E+00
Natural gas	Btu	4.82E+03	MJ	1.67E+01
Diesel	Btu	1.10E+04	MJ	3.81E+01
Water Usage				
Municipal Water Source	lbs	1.36E+02	kg	2.02E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	4.55E+04	MJ	1.57E+02
Energy from oil	Btu	1.22E+05	MJ	4.21E+02
Energy from natural gas	Btu	2.92E+05	MJ	1.01E+03
Energy from hydro power	Btu	2.58E+03	MJ	8.93E+00
Energy from uranium	Btu	2.79E+04	MJ	9.65E+01
Energy from lignite	Btu	7.79E+03	MJ	2.69E+01
Energy from biomass	Btu	2.02E+02	MJ	7.00E-01
Energy from hydrogen	Btu	4.90E+03	MJ	1.70E+01
Energy (undef.)	Btu	5.06E+02	MJ	1.75E+00
Energy from peat	Btu	1.52E+01	MJ	5.25E-02
Energy from sulphur	Btu	2.17E+02	MJ	7.52E-01
Energy from wood	Btu	1.82E+01	MJ	6.30E-02
Energy recovered	Btu	-2.34E+04	MJ	-8.10E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	1.93E+03	2.87E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	2.19E+02	3.26E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
PNW Bark on Logs	4.34E+01	6.50E+01
PNW Logs	8.51E+02	1.27E+03

Substance	lb per MLF	kg per 10^3m^3
Air	6.95E+00	1.03E+01
Baryte	3.00E-03	4.47E-03
Bauxite	3.55E-03	5.28E-03
Bentonite	1.63E-03	2.43E-03
Calcium sulphate	1.62E-04	2.41E-04
Chalk	1.92E-28	2.85E-28
Chromium (in ore)	1.15E-11	1.72E-11
Clay minerals	1.81E-04	2.69E-04
Coal FAL	1.02E+02	1.51E+02
Crude oil FAL	6.79E+01	1.01E+02
Dolomite	7.11E-04	1.06E-03
Feldspar	2.42E-34	3.61E-34
Ferromanganese	9.80E-06	1.46E-05
Fluorspar	5.31E-05	7.91E-05
Granite	3.95E-07	5.87E-07
Gravel	3.67E-05	5.46E-05
Iron (in ore)	1.15E-02	1.71E-02
KCl	2.12E-01	3.16E-01
Lead (in ore)	3.00E-05	4.47E-05
Limestone	7.11E+00	1.06E+01
NaCl	7.77E+00	1.16E+01
Natural gas FAL	1.45E+02	2.16E+02
Nickel (in ore)	1.81E-06	2.69E-06
Nitrogen	2.10E+00	3.12E+00
Olivine	9.85E-05	1.47E-04
Oxygen	2.47E+00	3.68E+00
Phosphate (as P2O5)	1.19E-04	1.77E-04
Rutile	2.75E-28	4.10E-28
Sand	1.35E-02	2.01E-02
Shale	4.59E-04	6.83E-04

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	6.02E+01	2.08E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	2.70E+04	9.33E+01
Energy (undef.)	7.07E+02	2.45E+00
Energy from biomass	2.70E+02	9.33E-01
Energy from coal	6.37E+04	2.21E+02
Energy from hydro power	5.54E+05	1.92E+03
Energy from hydrogen	6.86E+03	2.37E+01
Energy from lignite	1.09E+04	3.79E+01
Energy from natural gas	4.10E+05	1.42E+03
Energy from oil	1.71E+05	5.91E+02
Energy from peat	2.31E+01	8.00E-02
Energy from sulphur	3.21E+02	1.11E+00
Energy from uranium	3.91E+04	1.35E+02
Energy from wood	2.57E+01	8.88E-02
Energy recovered	-3.27E+04	-1.13E+02

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	5.16E+02	7.68E+02
Recycled Water	1.32E+00	1.97E+00
Well Water Source	1.18E+02	1.75E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	4.29E-10	6.38E-10
Acetaldehyde	1.06E-01	1.58E-01
Acetone	1.05E-02	1.56E-02
Acrolein	3.41E-02	5.07E-02
Aldehydes	4.39E-03	6.54E-03
Alpha-pinene	5.47E-02	8.14E-02
Ammonia	3.09E-03	4.60E-03
As	2.27E-05	3.38E-05
Ash	1.29E-04	1.92E-04
Ba	5.13E-04	7.64E-04
Be	1.18E-06	1.76E-06
Benzene	4.62E-04	6.88E-04
Beta-pinene	2.13E-02	3.17E-02
Cd	8.87E-06	1.32E-05
CFC (soft)	4.77E-05	7.10E-05
Cl_2	9.30E-04	1.38E-03
CO	4.50E+00	6.69E+00
CO_2	6.51E+01	9.69E+01

Southeast Bark	9.80E+01	1.46E+02
Southeast Hardwood Logs	3.09E+02	4.60E+02
Southeast Softwood Logs	9.25E+02	1.38E+03
Sulphur (bonded)	4.02E-02	5.99E-02
Sulphur (elemental)	8.10E-02	1.21E-01
Uranium FAL	5.16E-04	7.67E-04
Water	7.61E+01	1.13E+02
Water (cooling)	2.94E+02	4.38E+02
Water (drinking, for process.)	1.35E+03	2.01E+03
Water (process)	9.91E+00	1.47E+01
Water (sea, for cooling)	1.71E+03	2.55E+03
Water (sea, for processing)	6.13E+00	9.12E+00
Water (surface, for cooling)	2.55E+03	3.79E+03
Water (surface, for process.)	1.83E+01	2.72E+01
Water (well, for cooling)	8.10E-02	1.21E-01
Water (well, for processing)	5.97E-01	8.88E-01
Wood/wood wastes FAL	1.66E+01	2.48E+01
Zinc (in ore)	9.41E-07	1.40E-06

Other Raw Materials

Substance	Btu per MLF	MJ per 10^3m^3
Heat from DFO	7.94E+03	2.75E+01
Heat from Natural Gas	2.01E+04	6.97E+01
Hogged Fuel Direct Fired	1.88E+06	6.52E+03

Air Emissions-cont.

Substance	lb per MLF	kg per 10^3m^3
Cumene	3.24E-04	4.82E-04
C_xH_y	6.57E-02	9.77E-02
C_xH_y aromatic	1.20E-03	1.78E-03
C_xH_y chloro	2.00E-04	2.98E-04
Dichloromethane	1.47E-05	2.18E-05
Dioxin (TEQ)	1.93E-11	2.87E-11
Dust	7.83E-02	1.16E-01
F_2	4.53E-08	6.74E-08
Fe	5.13E-04	7.64E-04
Formaldehyde	1.75E-01	2.60E-01
H_2	2.97E-02	4.41E-02
H_2S	8.54E-06	1.27E-05
H_2SO_4	2.62E-04	3.90E-04
HCl	2.05E-02	3.05E-02
HCN	9.41E-34	1.40E-33
HF	2.64E-03	3.93E-03
Hg	1.46E-05	2.17E-05
K	9.08E-02	1.35E-01
Kerosene	1.14E-04	1.69E-04
Limonene	6.18E-03	9.20E-03
MDI (isocyanate)	1.16E-04	1.73E-04
CO_2 (biomass)	8.43E+02	1.25E+03
CO_2 (fossil)	5.45E+02	8.11E+02
CO_2 (non-fossil)	1.74E+01	2.59E+01
Cobalt	1.02E-05	1.51E-05
Cr	2.08E-05	3.09E-05
CS_2	4.11E-09	6.12E-09

Water Emissions

Substance	lb per MLF	kg per 10^3m^3
Acid as H+	1.05E-03	1.56E-03
Al	1.38E-04	2.06E-04
As	4.61E-09	6.86E-09
B	1.01E-02	1.50E-02
BOD	2.12E-02	3.15E-02
Ca	4.68E-07	6.96E-07
Calcium ions	1.95E-03	2.91E-03
Carbonate	2.43E-03	3.62E-03
Cd	3.50E-04	5.20E-04
Chromate	6.90E-06	1.03E-05
Cl-	2.70E+00	4.01E+00
Cl_2	1.84E-04	2.74E-04
COD	1.58E-01	2.35E-01
Cr	3.50E-04	5.20E-04
Cu	2.66E-06	3.96E-06
C_xH_y	6.46E-04	9.61E-04
C_xH_y chloro	5.43E-05	8.09E-05
Cyanide	7.50E-07	1.12E-06
Detergent/oil	6.40E-04	9.53E-04
Dissolved organics	5.64E-03	8.39E-03
Dissolved solids	7.83E+00	1.16E+01
Fe	1.42E-02	2.12E-02
Fluoride ions	4.53E-04	6.73E-04
H_2SO_4	2.52E-03	3.75E-03
Hg	5.33E-06	7.92E-06
K	6.07E-03	9.04E-03
Metallic ions	5.08E-03	7.57E-03
Mg	2.42E-04	3.60E-04
Mn	7.99E-03	1.19E-02
N-tot	1.05E-03	1.56E-03
Na	1.58E+00	2.35E+00
NH_3	3.14E-04	4.67E-04
NH_4+	3.37E-03	5.02E-03
Ni	1.26E-04	1.87E-04
Nitrate	2.58E-03	3.84E-03
Oil	1.37E-01	2.04E-01
Other organics	2.65E-02	3.94E-02
P_2O_5	1.55E-04	2.31E-04
Pb	1.13E-07	1.68E-07
Phenol	8.37E-05	1.25E-04

Mercaptans	1.20E-06	1.78E-06
Metals	1.94E-04	2.88E-04
Methane	1.71E+00	2.55E+00
Methanol	4.21E-01	6.26E-01
Methyl ethyl ketone	4.88E-04	7.26E-04
Methyl i-butyl ketone	3.98E-04	5.93E-04
Mn	1.08E-03	1.60E-03
N-nitrodimethylamine	6.79E-03	1.01E-02
N_2O	2.13E-03	3.17E-03
Na	2.10E-03	3.13E-03
Naphthalene	2.81E-04	4.18E-04
Ni	1.87E-04	2.78E-04
Non methane VOC	2.12E+00	3.15E+00
NO_x	3.96E+00	5.89E+00
Organic substances	2.52E-02	3.75E-02
Particulates	8.21E-01	1.22E+00
Particulates (PM10)	2.64E-01	3.93E-01
Particulates (unspecified)	2.61E-01	3.88E-01
Pb	1.57E-04	2.33E-04
Phenol	1.20E-01	1.78E-01
Propionaldehyde	4.08E-04	6.07E-04
Sb	3.98E-06	5.92E-06
Se	2.88E-05	4.29E-05
SO_2	1.75E-01	2.60E-01
SO_x	6.79E+00	1.01E+01
Tetrachloroethene	3.52E-06	5.24E-06
Tetrachloromethane	8.92E-06	1.33E-05
THC as Carbon	1.18E-01	1.75E-01
Trichloroethene	3.45E-06	5.13E-06
Vinyl chloride	4.27E-10	6.36E-10
VOC	2.16E+00	3.21E+00
Zn	5.14E-04	7.66E-04

Phosphate	1.26E-03	1.87E-03
Sulphate	4.31E-01	6.41E-01
Sulphur/sulphide	1.15E-05	1.71E-05
Suspended solids	2.48E-01	3.69E-01
Vinyl chloride	3.58E-31	5.33E-31
Zn	9.69E-04	1.44E-03

Solid Waste Emission

Substance	lb per MLF	kg per $10^3 m^3$
Boiler ash	3.06E+00	4.56E+00
Chemical waste (inert)	4.68E-02	6.97E-02
Chemical waste (regulated)	7.66E-02	1.14E-01
Construction waste	1.29E-03	1.92E-03
Industrial waste	1.73E-01	2.58E-01
Metal scrap	2.44E-04	3.62E-04
Mineral waste	1.38E+00	2.05E+00
Paper/board packaging	8.05E-05	1.20E-04
Plastics packaging	2.68E-03	3.98E-03
Slags/ash	3.42E-01	5.08E-01
Solid waste	7.01E+01	1.04E+02
Special waste	3.92E-03	5.84E-03
Unspecified	1.96E-04	2.92E-04
Waste in incineration	2.74E-02	4.08E-02
Waste to recycling	6.02E-03	8.96E-03
Wood packaging	1.31E-04	1.95E-04
Wood waste	3.31E-01	4.93E-01

Nonmaterial Emission

Substance	bq per MLF	bq per $10^3 m^3$
Radioactive sub. to air	2.95E+06	4.39E+06

Table A1.2. LCI data for 1.0 MLF of I-joists in the PNW with the dimensions of 11.875" in depth with flange dimensions of ~1.5"x 1.5".

LCI Inputs				
PNW I-joist –INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per 10^3m^3**
MDI (isocyante) Resin	lb	1.23E+01	kg	1.83E+01
Purchased				
Laminated Veneer Lumber	lb	9.02E+02	kg	1.34E+03
Oriented Strand Board	lb	1.33E+03	kg	1.98E+03
	I-joist Production, PNW			
Electrical Use				
Electricity	kWh	8.44E+01	MJ	9.97E+02
Fuel Use				
Liquid propane gas	Btu	1.47E+03	MJ	5.09E+00
Natural gas	Btu	5.03E+03	MJ	1.74E+01
Diesel	Btu	1.14E+04	MJ	3.95E+01
Water Usage				
Municipal Water Source	lb	1.42E+02	kg	2.11E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	4.75E+04	MJ	1.64E+02
Energy from oil	Btu	1.27E+05	MJ	4.40E+02
Energy from natural gas	Btu	3.05E+05	MJ	1.06E+03
Energy from hydro power	Btu	2.69E+03	MJ	9.32E+00
Energy from uranium	Btu	2.91E+04	MJ	1.01E+02
Energy from lignite	Btu	8.13E+03	MJ	2.81E+01
Energy from biomass	Btu	2.11E+02	MJ	7.31E-01
Energy from hydrogen	Btu	5.12E+03	MJ	1.77E+01
Energy (undef.)	Btu	5.28E+02	MJ	1.83E+00
Energy from peat	Btu	1.58E+01	MJ	5.48E-02
Energy from sulphur	Btu	2.27E+02	MJ	7.86E-01
Energy from wood	Btu	1.90E+01	MJ	6.58E-02
Energy recovered	Btu	-2.44E+04	MJ	-8.46E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.02E+03	3.00E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	2.29E+02	3.41E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
PNW Bark on Logs	3.67E+01	5.5.0E+01
PNW Logs	7.29E+02	1.08E+03

Substance	lb per MLF	kg per 10^3m^3
Air	7.72E+00	1.15E+01
Baryte	3.33E-03	4.96E-03
Bauxite	3.93E-03	5.85E-03
Bentonite	1.81E-03	2.69E-03
Calcium sulphate	1.80E-04	2.68E-04
Chalk	2.13E-28	3.16E-28
Chromium (in ore)	1.28E-11	1.91E-11
Clay minerals	2.01E-04	2.99E-04
Coal FAL	1.18E+02	1.76E+02
Crude oil FAL	7.55E+01	1.12E+02
Dolomite	7.95E-04	1.18E-03
Feldspar	2.69E-34	4.01E-34
Ferromanganese	1.09E-05	1.62E-05
Fluorspar	5.89E-05	8.76E-05
Granite	4.38E-07	6.52E-07
Gravel	4.07E-05	6.06E-05
Iron (in ore)	1.27E-02	1.90E-02
KCl	2.36E-01	3.50E-01
Lead (in ore)	3.34E-05	4.97E-05
Limestone	8.00E+00	1.19E+01
NaCl	8.63E+00	1.28E+01
Natural gas FAL	1.57E+02	2.33E+02
Nickel (in ore)	2.01E-06	2.99E-06
Nitrogen	2.33E+00	3.46E+00
Olivine	1.09E-04	1.62E-04
Oxygen	2.74E+00	4.08E+00
Phosphate (as P2O5)	1.32E-04	1.96E-04
Rutile	3.05E-28	4.54E-28
Sand	1.50E-02	2.24E-02

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	7.38E+01	2.55E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	3.06E+04	1.06E+02
Energy (undef.)	7.85E+02	2.72E+00
Energy from biomass	3.00E+02	1.04E+00
Energy from coal	7.07E+04	2.45E+02
Energy from hydro power	5.14E+05	1.78E+03
Energy from hydrogen	7.61E+03	2.63E+01
Energy from lignite	1.22E+04	4.21E+01
Energy from natural gas	4.55E+05	1.57E+03
Energy from oil	1.89E+05	6.55E+02
Energy from peat	2.57E+01	8.89E-02
Energy from sulphur	3.57E+02	1.23E+00
Energy from uranium	4.34E+04	1.50E+02
Energy from wood	2.84E+01	9.84E-02
Energy recovered	-3.64E+04	-1.26E+02

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	4.65E+02	6.92E+02
Recycled Water	1.13E+00	1.68E+00
Well Water Source	1.01E+02	1.50E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	4.76E-10	7.09E-10
Acetaldehyde	1.26E-01	1.88E-01
Acetone	8.97E-03	1.34E-02
Acrolein	4.18E-02	6.23E-02
Aldehydes	4.79E-03	7.13E-03
Alpha-pinene	4.71E-02	7.01E-02
Ammonia	3.40E-03	5.06E-03
As	2.34E-05	3.48E-05
Ash	1.59E-04	2.36E-04
Ba	4.40E-04	6.54E-04
Be	1.38E-06	2.06E-06
Benzene	4.05E-04	6.03E-04
Beta-pinene	1.82E-02	2.71E-02
Cd	1.05E-05	1.57E-05
CFC (soft)	5.29E-05	7.88E-05
Cl_2	8.00E-04	1.19E-03
CO	4.74E+00	7.06E+00

Shale	5.10E-04	7.59E-04
Southeast Bark	1.20E+02	1.79E+02
Southeast Hardwood Logs	3.80E+02	5.65E+02
Southeast Softwood Logs	1.14E+03	1.69E+03
Sulphur (bonded)	4.46E-02	6.64E-02
Sulphur (elemental)	8.97E-02	1.34E-01
Uranium FAL	6.00E-04	8.93E-04
Water	9.37E+01	1.39E+02
Water (cooling)	3.27E+02	4.87E+02
Water (drinking, for process.)	1.50E+03	2.23E+03
Water (process)	1.10E+01	1.63E+01
Water (sea, for cooling)	1.90E+03	2.82E+03
Water (sea, for processing)	6.80E+00	1.01E+01
Water (surface, for cooling)	2.83E+03	4.21E+03
Water (surface, for process.)	2.03E+01	3.02E+01
Water (well, for cooling)	8.97E-02	1.34E-01
Water (well, for processing)	6.57E-01	9.78E-01
Wood/wood wastes FAL	1.43E+01	2.13E+01
Zinc (in ore)	1.05E-06	1.56E-06

Other Raw Materials

Substance	Btu per MLF	MJ per 10^3m^3
Heat from DFO	9.79E+03	3.39E+01
Heat from Natural Gas	2.47E+04	8.55E+01
Hogged Fuel Direct Fired	2.29E+06	7.91E+03

Air Emissions-cont.

Substance	lb per MLF	kg per 10^3m^3
Cumene	3.45E-04	5.14E-04
C_xH_y	7.32E-02	1.09E-01
C_xH_y aromatic	1.33E-03	1.97E-03
C_xH_y chloro	2.22E-04	3.31E-04
Dichloromethane	1.71E-05	2.55E-05
Dioxin (TEQ)	2.25E-11	3.35E-11
Dust	8.63E-02	1.28E-01
F_2	5.02E-08	7.48E-08
Fe	4.40E-04	6.54E-04
Formaldehyde	1.95E-01	2.91E-01
H_2	3.29E-02	4.90E-02
H_2S	9.43E-06	1.40E-05
H_2SO_4	2.91E-04	4.33E-04
HCl	2.38E-02	3.54E-02
CO_2	7.32E+01	1.09E+02
CO_2 (biomass)	9.43E+02	1.40E+03
CO_2 (fossil)	6.12E+02	9.10E+02
CO_2 (non-fossil)	1.50E+01	2.23E+01
Cobalt	1.19E-05	1.78E-05
Cr	2.27E-05	3.38E-05
CS_2	4.56E-09	6.79E-09

Water Emissions

Substance	lb per MLF	kg per 10^3m^3
Acid as H+	1.20E-03	1.79E-03
Al	1.54E-04	2.29E-04
As	5.12E-09	7.61E-09
B	1.18E-02	1.75E-02
BOD	2.33E-02	3.46E-02
Ca	5.02E-07	7.48E-07
Calcium ions	2.17E-03	3.23E-03
Carbonate	2.70E-03	4.01E-03
Cd	3.78E-04	5.63E-04
Chromate	8.12E-06	1.21E-05
Cl-	2.98E+00	4.44E+00
Cl_2	2.04E-04	3.04E-04
COD	1.74E-01	2.59E-01
Cr	3.78E-04	5.63E-04
Cu	2.96E-06	4.40E-06
C_xH_y	7.15E-04	1.06E-03
C_xH_y chloro	6.06E-05	9.02E-05
Cyanide	8.17E-07	1.22E-06
Detergent/oil	7.09E-04	1.05E-03
Dissolved organics	6.29E-03	9.36E-03
Dissolved solids	8.46E+00	1.26E+01
Fe	1.66E-02	2.48E-02
Fluoride ions	5.28E-04	7.85E-04
H_2SO_4	2.94E-03	4.38E-03
Hg	5.89E-06	8.76E-06
K	6.75E-03	1.00E-02
Metallic ions	5.61E-03	8.34E-03
Mg	2.68E-04	3.99E-04
Mn	9.26E-03	1.38E-02
N-tot	1.16E-03	1.73E-03
Na	1.75E+00	2.61E+00
NH_3	3.54E-04	5.27E-04
NH_4+	3.74E-03	5.57E-03

HCN	1.05E-33	1.56E-33
HF	3.07E-03	4.57E-03
Hg	1.67E-05	2.48E-05
K	7.77E-02	1.16E-01
Kerosene	1.32E-04	1.96E-04
Limonene	5.29E-03	7.87E-03
MDI (isocyanate)	1.42E-04	2.12E-04
Mercaptans	1.33E-06	1.97E-06
Metals	2.16E-04	3.22E-04
Methane	1.90E+00	2.82E+00
Methanol	4.69E-01	6.97E-01
Methyl ethyl ketone	4.18E-04	6.22E-04
Methyl i-butyl ketone	3.41E-04	5.08E-04
Mn	9.32E-04	1.39E-03
N-nitrodimethylamine	8.35E-03	1.24E-02
N_2O	2.49E-03	3.70E-03
Na	1.80E-03	2.68E-03
Naphthalene	2.41E-04	3.58E-04
Ni	1.99E-04	2.97E-04
Non methane VOC	2.28E+00	3.39E+00
NO_x	4.33E+00	6.45E+00
Organic substances	2.30E-02	3.42E-02
Particulates	8.75E-01	1.30E+00
Particulates (PM10)	2.44E-01	3.62E-01
Particulates (unspecified)	3.04E-01	4.53E-01
Pb	1.39E-04	2.08E-04
Phenol	1.29E-01	1.91E-01
Propionaldehyde	3.49E-04	5.20E-04
Sb	4.68E-06	6.97E-06
Se	3.37E-05	5.01E-05
SO_2	2.14E-01	3.18E-01
SO_x	7.49E+00	1.11E+01
Tetrachloroethene	4.11E-06	6.12E-06
Tetrachloromethane	1.06E-05	1.57E-05
THC as Carbon	1.01E-01	1.51E-01
Trichloroethene	4.02E-06	5.99E-06
Vinyl chloride	4.74E-10	7.06E-10
VOC	2.43E+00	3.61E+00
Zn	4.41E-04	6.56E-04

Ni	1.39E-04	2.08E-04
Nitrate	2.86E-03	4.25E-03
Oil	1.48E-01	2.20E-01
Other organics	2.89E-02	4.30E-02
P_2O_5	1.73E-04	2.57E-04
Pb	1.22E-07	1.82E-07
Phenol	9.26E-05	1.38E-04
Phosphate	1.47E-03	2.19E-03
Sulphate	4.74E-01	7.05E-01
Sulphur/sulphide	1.27E-05	1.90E-05
Suspended solids	2.83E-01	4.21E-01
Vinyl chloride	3.98E-31	5.92E-31
Zn	1.07E-03	1.59E-03

Solid Waste Emission

Substance	lb per MLF	kg per $10^3 m^3$
Boiler ash	3.76E+00	5.59E+00
Chemical waste (inert)	5.20E-02	7.73E-02
Chemical waste (regulated)	8.52E-02	1.27E-01
Construction waste	1.43E-03	2.13E-03
Industrial waste	1.93E-01	2.87E-01
Metal scrap	2.70E-04	4.02E-04
Mineral waste	1.53E+00	2.28E+00
Paper/board packaging	8.92E-05	1.33E-04
Plastics packaging	2.97E-03	4.42E-03
Slags/ash	3.79E-01	5.64E-01
Solid waste	7.77E+01	1.16E+02
Special waste	4.81E-03	7.16E-03
Unspecified	2.18E-04	3.24E-04
Waste in incineration	3.04E-02	4.53E-02
Waste to recycling	6.69E-03	9.95E-03
Wood packaging	1.45E-04	2.16E-04
Wood waste	4.06E-01	6.04E-01

Nonmaterial Emission

Substance	bq per MLF	bq per $10^3 m^3$
Radioactive sub. to air	3.33E+06	4.95E+06

Table A1.3. LCI data for 1.0 MLF of I-joists in the PNW with the dimensions of 11.875" in depth with flange dimensions of ~1.5"x 1.75".

LCI Inputs

PNW I-joist –INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per $10^3 m^3$**
MDI (isocyanate) Resin	lb	1.31E+01	kg	1.95E+01
Purchased				
Laminated Veneer Lumber	lb	1.05E+03	kg	1.57E+03
Oriented Strand Board	lb	1.33E+03	kg	1.98E+03
	I-joist Production, PNW			
Electrical Use				
Electricity	kWh	9.01E+01	MJ	1.06E+03
Fuel Use				
Liquid propane gas	Btu	1.62E+03	MJ	5.60E+00
Natural gas	Btu	5.37E+03	MJ	1.86E+01
Diesel	Btu	1.23E+04	MJ	4.25E+01
Water Usage				
Municipal Water Source	lbs	1.51E+02	kg	2.25E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	5.08E+04	MJ	1.76E+02
Energy from oil	Btu	1.36E+05	MJ	4.70E+02
Energy from natural gas	Btu	3.26E+05	MJ	1.13E+03
Energy from hydro power	Btu	2.88E+03	MJ	9.96E+00
Energy from uranium	Btu	3.11E+04	MJ	1.08E+02
Energy from lignite	Btu	8.69E+03	MJ	3.01E+01
Energy from biomass	Btu	2.26E+02	MJ	7.81E-01
Energy from hydrogen	Btu	5.47E+03	MJ	1.89E+01
Energy (undef.)	Btu	5.64E+02	MJ	1.95E+00
Energy from peat	Btu	1.69E+01	MJ	5.86E-02
Energy from sulphur	Btu	2.43E+02	MJ	8.39E-01
Energy from wood	Btu	2.03E+01	MJ	7.03E-02
Energy recovered	Btu	-2.61E+04	MJ	-9.04E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.15E+03	3.20E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	2.45E+02	3.64E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
PNW Bark on Logs	4.28E+01	6.40+01
PNW Logs	8.51E+02	1.27E+03

Substance	lb per MLF	kg per 10^3m^3
Air	7.99E+00	1.19E+01
Baryte	3.47E-03	5.16E-03
Bauxite	4.09E-03	6.09E-03
Bentonite	1.88E-03	2.80E-03
Calcium sulphate	1.87E-04	2.79E-04
Chalk	2.21E-28	3.29E-28
Chromium (in ore)	1.34E-11	1.99E-11
Clay minerals	2.09E-04	3.10E-04
Coal FAL	1.21E+02	1.80E+02
Crude oil FAL	7.87E+01	1.17E+02
Dolomite	8.23E-04	1.22E-03
Feldspar	2.80E-34	4.16E-34
Ferromanganese	1.13E-05	1.69E-05
Fluorspar	6.16E-05	9.16E-05
Granite	4.56E-07	6.78E-07
Gravel	4.23E-05	6.30E-05
Iron (in ore)	1.33E-02	1.98E-02
KCl	2.45E-01	3.65E-01
Lead (in ore)	3.47E-05	5.16E-05
Limestone	8.29E+00	1.23E+01
NaCl	8.96E+00	1.33E+01
Natural gas FAL	1.65E+02	2.45E+02
Nickel (in ore)	2.09E-06	3.10E-06
Nitrogen	2.42E+00	3.60E+00
Olivine	1.13E-04	1.69E-04
Oxygen	2.85E+00	4.25E+00
Phosphate (as P2O5)	1.37E-04	2.04E-04
Rutile	3.18E-28	4.73E-28
Sand	1.56E-02	2.32E-02

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	7.38E+01	2.55E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	3.16E+04	1.09E+02
Energy (undef.)	8.17E+02	2.83E+00
Energy from biomass	3.12E+02	1.08E+00
Energy from coal	7.36E+04	2.55E+02
Energy from hydro power	5.78E+05	2.00E+03
Energy from hydrogen	7.92E+03	2.74E+01
Energy from lignite	1.26E+04	4.36E+01
Energy from natural gas	4.73E+05	1.64E+03
Energy from oil	1.97E+05	6.82E+02
Energy from peat	2.67E+01	9.25E-02
Energy from sulphur	3.72E+02	1.29E+00
Energy from uranium	4.51E+04	1.56E+02
Energy from wood	2.97E+01	1.03E-01
Energy recovered	-3.79E+04	-1.31E+02

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	5.30E+02	7.88E+02
Recycled Water	1.32E+00	1.96E+00
Well Water Source	1.18E+02	1.75E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	4.95E-10	7.37E-10
Acetaldehyde	1.27E-01	1.90E-01
Acetone	1.03E-02	1.53E-02
Acrolein	4.20E-02	6.24E-02
Aldehydes	5.02E-03	7.47E-03
Alpha-pinene	5.49E-02	8.18E-02
Ammonia	3.55E-03	5.28E-03
As	2.51E-05	3.74E-05
Ash	1.59E-04	2.36E-04
Ba	5.13E-04	7.63E-04
Be	1.41E-06	2.10E-06
Benzene	4.68E-04	6.96E-04
Beta-pinene	2.13E-02	3.17E-02
Cd	1.06E-05	1.58E-05
CFC (soft)	5.51E-05	8.20E-05
Cl_2	9.33E-04	1.39E-03
CO	5.04E+00	7.50E+00

Shale	5.31E-04	7.89E-04
Southeast Bark	1.20E+02	1.79E+02
Southeast Hardwood Logs	3.79E+02	5.64E+02
Southeast Softwood Logs	1.13E+03	1.69E+03
Sulphur (bonded)	4.65E-02	6.91E-02
Sulphur (elemental)	9.33E-02	1.39E-01
Uranium FAL	6.10E-04	9.07E-04
Water	9.33E+01	1.39E+02
Water (cooling)	3.40E+02	5.06E+02
Water (drinking, for process.)	1.56E+03	2.32E+03
Water (process)	1.15E+01	1.71E+01
Water (sea, for cooling)	1.98E+03	2.94E+03
Water (sea, for processing)	7.07E+00	1.05E+01
Water (surface, for cooling)	2.95E+03	4.38E+03
Water (surface, for process.)	2.11E+01	3.14E+01
Water (well, for cooling)	9.33E-02	1.39E-01
Water (well, for processing)	6.83E-01	1.02E+00
Wood/wood wastes FAL	1.66E+01	2.48E+01
Zinc (in ore)	1.09E-06	1.62E-06

Other Raw Materials

Substance	Btu per MLF	MJ per $10^3 m^3$
Heat from DFO	9.74E+03	3.37E+01
Heat from Natural Gas	2.47E+04	8.54E+01
Hogged Fuel Direct Fired	2.29E+06	7.93E+03

Air Emissions-cont.

Substance	lb per MLF	kg per $10^3 m^3$
Cumene	3.65E-04	5.44E-04
C_xH_y	7.62E-02	1.13E-01
C_xH_y aromatic	1.38E-03	2.05E-03
C_xH_y chloro	2.31E-04	3.44E-04
Dichloromethane	1.74E-05	2.60E-05
Dioxin (TEQ)	2.29E-11	3.41E-11
Dust	9.03E-02	1.34E-01
F_2	5.23E-08	7.79E-08
Fe	5.13E-04	7.63E-04
Formaldehyde	2.02E-01	3.01E-01
H_2	3.43E-02	5.10E-02
H_2S	9.82E-06	1.46E-05
H_2SO_4	3.03E-04	4.51E-04
HCl	2.43E-02	3.61E-02
HCN	1.09E-33	1.62E-33
HF	3.13E-03	4.65E-03
Hg	1.72E-05	2.56E-05
K	9.09E-02	1.35E-01
Kerosene	1.35E-04	2.01E-04
Limonene	6.16E-03	9.16E-03
CO_2	7.56E+01	1.13E+02
CO_2 (biomass)	9.76E+02	1.45E+03
CO_2 (fossil)	6.34E+02	9.44E+02
CO_2 (non-fossil)	1.74E+01	2.60E+01
Cobalt	1.21E-05	1.81E-05
Cr	2.38E-05	3.54E-05
CS_2	4.74E-09	7.06E-09

Water Emissions

Substance	lb per MLF	kg per $10^3 m^3$
Acid as H+	1.23E-03	1.83E-03
Al	1.60E-04	2.39E-04
As	5.32E-09	7.92E-09
B	1.20E-02	1.79E-02
BOD	2.43E-02	3.62E-02
Ca	5.30E-07	7.89E-07
Calcium ions	2.26E-03	3.36E-03
Carbonate	2.81E-03	4.17E-03
Cd	3.98E-04	5.93E-04
Chromate	8.23E-06	1.22E-05
Cl-	3.11E+00	4.63E+00
Cl_2	2.13E-04	3.17E-04
COD	1.82E-01	2.70E-01
Cr	3.98E-04	5.93E-04
Cu	3.07E-06	4.57E-06
C_xH_y	7.44E-04	1.11E-03
C_xH_y chloro	6.28E-05	9.35E-05
Cyanide	8.54E-07	1.27E-06
Detergent/oil	7.38E-04	1.10E-03
Dissolved organics	6.52E-03	9.71E-03
Dissolved solids	8.90E+00	1.32E+01
Fe	1.70E-02	2.52E-02
Fluoride ions	5.38E-04	8.00E-04
H_2SO_4	3.00E-03	4.46E-03
Hg	6.16E-06	9.16E-06
K	7.01E-03	1.04E-02
Metallic ions	5.85E-03	8.70E-03
Mg	2.79E-04	4.16E-04
Mn	9.45E-03	1.41E-02
N-tot	1.21E-03	1.80E-03
Na	1.82E+00	2.71E+00
NH_3	3.65E-04	5.44E-04
NH_4+	3.89E-03	5.79E-03
Ni	1.45E-04	2.16E-04
Nitrate	2.98E-03	4.43E-03
Oil	1.56E-01	2.32E-01
Other organics	3.03E-02	4.51E-02
P_2O_5	1.80E-04	2.68E-04
Pb	1.28E-07	1.91E-07

MDI (isocyanate)	1.42E-04	2.11E-04
Mercaptans	1.38E-06	2.06E-06
Metals	2.24E-04	3.34E-04
Methane	1.98E+00	2.94E+00
Methanol	4.85E-01	7.22E-01
Methyl ethyl ketone	4.88E-04	7.26E-04
Methyl i-butyl ketone	3.98E-04	5.93E-04
Mn	1.09E-03	1.62E-03
N-nitrodimethylamine	8.29E-03	1.23E-02
N_2O	2.53E-03	3.77E-03
Na	2.10E-03	3.12E-03
Naphthalene	2.81E-04	4.17E-04
Ni	2.11E-04	3.14E-04
Non methane VOC	2.40E+00	3.57E+00
NO_x	4.53E+00	6.74E+00
Organic substances	2.60E-02	3.87E-02
Particulates	9.21E-01	1.37E+00
Particulates (PM10)	2.75E-01	4.09E-01
Particulates (unspecified)	3.10E-01	4.62E-01
Pb	1.60E-04	2.38E-04
Phenol	1.36E-01	2.02E-01
Propionaldehyde	4.07E-04	6.06E-04
Sb	4.76E-06	7.08E-06
Se	3.43E-05	5.11E-05
SO_2	2.13E-01	3.18E-01
SO_x	7.81E+00	1.16E+01
Tetrachloroethene	4.19E-06	6.23E-06
Tetrachloromethane	1.07E-05	1.60E-05
THC as Carbon	1.18E-01	1.75E-01
Trichloroethene	4.10E-06	6.10E-06
Vinyl chloride	4.94E-10	7.35E-10
VOC	2.51E+00	3.74E+00
Zn	5.14E-04	7.65E-04

Phenol	9.64E-05	1.43E-04
Phosphate	1.50E-03	2.23E-03
Sulphate	4.95E-01	7.36E-01
Sulphur/sulphide	1.33E-05	1.98E-05
Suspended solids	2.91E-01	4.33E-01
Vinyl chloride	4.14E-31	6.16E-31
Zn	1.12E-03	1.66E-03

Solid Waste Emission

Substance	**lb per MLF**	**kg per $10^3 m^3$**
Boiler ash	3.76E+00	5.59E+00
Chemical waste (inert)	5.41E-02	8.05E-02
Chemical waste (regulated)	8.90E-02	1.32E-01
Construction waste	1.49E-03	2.22E-03
Industrial waste	2.00E-01	2.98E-01
Metal scrap	2.81E-04	4.18E-04
Mineral waste	1.60E+00	2.38E+00
Paper/board packaging	9.27E-05	1.38E-04
Plastics packaging	3.09E-03	4.60E-03
Slags/ash	3.95E-01	5.87E-01
Solid waste	8.05E+01	1.20E+02
Special waste	4.81E-03	7.15E-03
Unspecified	2.26E-04	3.37E-04
Waste in incineration	3.16E-02	4.71E-02
Waste to recycling	7.01E-03	1.04E-02
Wood packaging	1.51E-04	2.25E-04
Wood waste	4.06E-01	6.03E-01

Nonmaterial Emission

Substance	**bq per MLF**	**bq per $10^3 m^3$**
Radioactive sub. to air	3.44E+06	5.13E+06

Table A1.4. LCI data for 1.0 MLF of I-joists in the SE with the dimensions of 9.5" in depth with flange dimensions of ~1.5"x 1.75".

LCI Inputs

Material	Units	per MLF	SI Units	per 10^3m^3
SE I-joist -INPUTS				
MDI (isocyanate) Resin	lb	4.33E+00	kg	6.44E+00
PRF Resin	lb	2.56E+00	kg	3.81E+00
Purchased				
Laminated Veneer Lumber	lb	1.38E+03	kg	2.05E+03
Oriented Strand Board	lb	9.51E+02	kg	1.42E+03
	I-joist Production, SE			
Electrical Use				
Electricity	kWh	6.31E+01	MJ	7.45E+02
Fuel Use				
Liquid propane gas	Btu	2.93E+04	MJ	1.01E+02
Natural gas	Btu	5.26E+04	MJ	1.82E+02
Diesel	Btu	3.47E+04	MJ	1.20E+02
Water Usage				
Municipal Water Source	lbs	4.35E+01	kg	6.47E+01
Recycled Water	lbs	2.00E+00	kg	2.98E+00
Well Water Source	lbs	2.80E+00	kg	4.17E+00
	PF (PRF) Resin Production			
Electrical Use				
Electricity	kWh	1.64E+00	MJ	1.94E+01
Fuel Use				
Heavy oil	Btu	1.60E+03	MJ	5.53E+00
Natural gas	Btu	1.10E+01	MJ	3.81E-02
Diesel	Btu	2.97E+04	MJ	1.03E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	1.68E+04	MJ	5.80E+01
Energy from oil	Btu	4.48E+04	MJ	1.55E+02
Energy from natural gas	Btu	1.08E+05	MJ	3.73E+02
Energy from hydro power	Btu	9.51E+02	MJ	3.29E+00
Energy from uranium	Btu	1.03E+04	MJ	3.55E+01
Energy from lignite	Btu	2.87E+03	MJ	9.93E+00
Energy from biomass	Btu	7.46E+01	MJ	2.58E-01
Energy from hydrogen	Btu	1.81E+03	MJ	6.25E+00
Energy (undef.)	Btu	1.86E+02	MJ	6.45E-01

Energy from peat	Btu	5.59E+00	MJ	1.93E-02
Energy from sulphur	Btu	8.01E+01	MJ	2.77E-01
Energy from wood	Btu	6.71E+00	MJ	2.32E-02
Energy recovered	Btu	-8.63E+03	MJ	-2.99E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.17E+03	3.23E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	1.64E+02	2.44E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
SE Bark on Logs	5.90E+01	8.80E+01
SE Logs	1.18E+03	1.75E+03

Substance	lb per MLF	kg per 10^3m^3
Air	3.97E+00	5.91E+00
Baryte	1.72E-03	2.56E-03
Bauxite	2.03E-03	3.02E-03
Bentonite	9.34E-04	1.39E-03
Calcium sulphate	9.28E-05	1.38E-04
Chalk	1.10E-28	1.64E-28
Chromium (in ore)	6.62E-12	9.85E-12
Clay minerals	1.03E-04	1.54E-04
Coal FAL	1.80E+02	2.68E+02
Crude oil FAL	7.24E+01	1.08E+02
Dolomite	4.09E-04	6.09E-04
Feldspar	1.39E-34	2.07E-34
Ferromanganese	5.61E-06	8.35E-06
Fluorspar	3.04E-05	4.53E-05
Granite	2.26E-07	3.36E-07
Gravel	2.10E-05	3.13E-05
Iron (in ore)	6.56E-03	9.76E-03
KCl	1.22E-01	1.81E-01
Lead (in ore)	1.72E-05	2.56E-05
Limestone	1.35E+01	2.01E+01
NaCl	4.46E+00	6.63E+00
Natural gas FAL	1.77E+02	2.63E+02
Nickel (in ore)	1.03E-06	1.54E-06
Nitrogen	1.20E+00	1.79E+00

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	5.48E+01	1.90E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	4.20E+04	1.45E+02
Energy (undef.)	4.05E+02	1.40E+00
Energy from biomass	1.54E+02	5.34E-01
Energy from coal	3.65E+04	1.26E+02
Energy from hydro power	2.39E+04	8.26E+01
Energy from hydrogen	3.93E+03	1.36E+01
Energy from lignite	6.26E+03	2.17E+01
Energy from natural gas	2.35E+05	8.12E+02
Energy from oil	9.77E+04	3.38E+02
Energy from peat	1.33E+01	4.59E-02
Energy from sulphur	1.84E+02	6.37E-01
Energy from uranium	2.24E+04	7.74E+01
Energy from wood	1.47E+01	5.07E-02
Energy recovered	-1.88E+04	-6.51E+01

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	5.47E+02	8.13E+02
Recycled Water	2.23E+01	3.31E+01
Well Water Source	4.72E+02	7.02E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	2.46E-10	3.66E-10
Acetaldehyde	8.79E-02	1.31E-01
Acetone	2.81E-02	4.18E-02
Acrolein	3.11E-02	4.63E-02
Aldehydes	5.15E-03	7.66E-03
Ammonia	3.45E-03	5.14E-03
As	3.98E-05	5.92E-05
Ash	1.18E-04	1.76E-04
Ba	8.72E-04	1.30E-03
Be	2.13E-06	3.17E-06
Benzene	7.55E-04	1.12E-03
Cd	1.66E-05	2.47E-05

Olivine	5.63E-05	8.38E-05
Oxygen	1.42E+00	2.11E+00
Phosphate (as P2O5)	6.81E-05	1.01E-04
Rutile	1.58E-28	2.35E-28
Sand	7.73E-03	1.15E-02
Shale	2.63E-04	3.91E-04
Southeast Bark	8.91E+01	1.33E+02
Southeast Hardwood Logs	2.82E+02	4.20E+02
Southeast Softwood Logs	8.48E+02	1.26E+03
Sulphur (bonded)	2.31E-02	3.43E-02
Sulphur (elemental)	4.63E-02	6.90E-02
Uranium FAL	9.10E-04	1.35E-03
Water	6.93E+01	1.03E+02
Water (cooling)	1.69E+02	2.51E+02
Water (drinking, for process.)	7.73E+02	1.15E+03
Water (process)	5.67E+00	8.44E+00
Water (sea, for cooling)	9.78E+02	1.45E+03
Water (sea, for processing)	3.51E+00	5.22E+00
Water (surface, for cooling)	1.46E+03	2.17E+03
Water (surface, for process.)	1.05E+01	1.56E+01
Water (well, for cooling)	4.64E-02	6.91E-02
Water (well, for processing)	3.40E-01	5.06E-01
Wood/wood wastes FAL	5.12E+01	7.62E+01
Zinc (in ore)	5.39E-07	8.02E-07

Other Raw Materials

Substance	Btu per MLF	MJ per 10^3m^3
Heat from DFO	7.25E+03	2.51E+01
Heat from Natural Gas	1.83E+04	6.34E+01
Hogged Fuel Direct Fired	1.66E+06	5.76E+03

Air Emissions-cont.

Substance	lb per MLF	kg per 10^3m^3
CS_2	2.36E-09	3.51E-09
Cumene	3.03E-04	4.50E-04
C_xH_y	3.77E-02	5.61E-02
C_xH_y aromatic	6.87E-04	1.02E-03
C_xH_y chloro	1.15E-04	1.71E-04
Dichloromethane	2.60E-05	3.88E-05
Dioxin (TEQ)	3.42E-11	5.08E-11
Dust	4.47E-02	6.66E-02
F_2	2.59E-08	3.86E-08
Fe	8.72E-04	1.30E-03
Formaldehyde	1.51E-01	2.25E-01
H_2	1.70E-02	2.53E-02
H_2S	4.88E-06	7.26E-06
H_2SO_4	1.50E-04	2.24E-04
CFC (soft)	2.73E-05	4.07E-05
Cl_2	1.57E-03	2.33E-03
CO	5.72E+00	8.51E+00
CO_2	4.05E+01	6.02E+01
CO_2 (biomass)	9.16E+02	1.36E+03
CO_2 (fossil)	7.92E+02	1.18E+03
CO_2 (non-fossil)	5.35E+01	7.96E+01
Cobalt	1.88E-05	2.80E-05
Cr	3.68E-05	5.48E-05

Water Emissions

Substance	lb per MLF	kg per 10^3m^3
Acid as H+	7.18E-04	1.07E-03
Al	7.92E-05	1.18E-04
As	2.64E-09	3.93E-09
B	1.80E-02	2.68E-02
BOD	1.70E-02	2.53E-02
Ca	4.36E-07	6.49E-07
Calcium ions	1.24E-03	1.84E-03
Carbonate	1.39E-03	2.07E-03
Cd	4.27E-04	6.35E-04
Chromate	1.30E-05	1.93E-05
Cl-	1.78E+00	2.64E+00
Cl_2	1.05E-04	1.57E-04
COD	1.37E-01	2.03E-01
Cr	4.27E-04	6.35E-04
Cu	1.53E-06	2.27E-06
C_xH_y	3.69E-04	5.49E-04
C_xH_y chloro	3.11E-05	4.63E-05
Cyanide	7.67E-07	1.14E-06
Detergent/oil	3.67E-04	5.46E-04
Dissolved organics	3.32E-03	4.94E-03
Dissolved solids	9.47E+00	1.41E+01
Fe	2.52E-02	3.75E-02
Fluoride ions	7.98E-04	1.19E-03
H_2SO_4	4.50E-03	6.69E-03
Hg	3.07E-06	4.57E-06
K	3.49E-03	5.19E-03
Metallic ions	3.56E-03	5.29E-03
Mg	1.39E-04	2.06E-04
Mn	1.41E-02	2.10E-02
N-tot	5.99E-04	8.91E-04
Na	9.03E-01	1.34E+00
NH_3	4.67E-04	6.94E-04
NH_4+	1.93E-03	2.87E-03
Ni	7.18E-05	1.07E-04
Nitrate	1.53E-03	2.27E-03
Oil	1.67E-01	2.49E-01

HCl	3.37E-02	5.01E-02
HCN	5.39E-34	8.02E-34
HF	4.55E-03	6.77E-03
Hg	1.80E-05	2.68E-05
K	1.55E-01	2.30E-01
Kerosene	2.00E-04	2.98E-04
MDI (isocyanate)	1.06E-04	1.57E-04
Mercaptans	6.87E-07	1.02E-06
Metals	1.83E-04	2.72E-04
Methane	2.16E+00	3.21E+00
Methanol	3.84E-01	5.71E-01
Mn	1.83E-03	2.73E-03
N-nitrodimethylamine	6.18E-03	9.20E-03
N_2O	3.79E-03	5.63E-03
Na	3.56E-03	5.30E-03
Naphthalene	4.76E-04	7.08E-04
Ni	3.40E-04	5.05E-04
Non methane VOC	2.44E+00	3.63E+00
NO_x	5.00E+00	7.44E+00
Organic substances	3.94E-02	5.86E-02
Particulates	5.62E-01	8.36E-01
Particulates (PM10)	1.17E+00	1.74E+00
Particulates (unspecified)	4.60E-01	6.85E-01
Pb	2.65E-04	3.95E-04
Phenol	1.13E-01	1.68E-01
Sb	7.36E-06	1.10E-05
Se	5.11E-05	7.60E-05
SO_2	1.59E-01	2.37E-01
SO_x	9.03E+00	1.34E+01
Tetrachloroethene	6.25E-06	9.30E-06
Tetrachloromethane	1.70E-05	2.52E-05
Trichloroethene	6.11E-06	9.09E-06
Vinyl chloride	2.45E-10	3.65E-10
VOC	1.53E+00	2.27E+00
Water vapor	5.60E+02	8.33E+02
Zn	8.72E-04	1.30E-03

Other organics	3.17E-02	4.72E-02
P_2O_5	8.91E-05	1.33E-04
Pb	1.19E-07	1.77E-07
Phenol	4.99E-05	7.43E-05
Phosphate	2.25E-03	3.35E-03
Sulphate	4.91E-01	7.31E-01
Sulphur/sulphide	6.56E-06	9.76E-06
Suspended solids	3.67E-01	5.46E-01
Vinyl chloride	2.05E-31	3.06E-31
Zn	6.31E-04	9.39E-04

Solid Waste Emission

Substance	lb per MLF	kg per $10^3 m^3$
Boiler ash	2.79E+00	4.15E+00
Chemical waste (inert)	2.69E-02	4.00E-02
Chemical waste (regulated)	4.41E-02	6.56E-02
Construction waste	7.43E-04	1.10E-03
Industrial waste	9.96E-02	1.48E-01
Metal scrap	1.40E-04	2.08E-04
Mineral waste	7.92E-01	1.18E+00
Paper/board packaging	4.60E-05	6.85E-05
Plastics packaging	1.53E-03	2.28E-03
Slags/ash	1.96E-01	2.91E-01
Solid waste	1.16E+02	1.72E+02
Special waste	3.58E-03	5.32E-03
Unspecified	1.13E-04	1.68E-04
Waste in incineration	1.57E-02	2.34E-02
Waste to recycling	3.47E-03	5.16E-03
Wood packaging	7.49E-05	1.11E-04
Wood waste	3.02E-01	4.49E-01

Nonmaterial Emission

Substance	bq per MLF	bq per $10^3 m^3$
Radioactive sub. to air	4.44E+06	6.60E+06

Table A1.5. LCI data for 1.0 MLF of I-joists in the SE with the dimensions of 11.875” in depth with flange dimensions of ~1.5”x 1.5”.

LCI Inputs				
SE I-joist -INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per 10^3m^3**
MDI (isocyanate) Resin	lb	4.72E+00	kg	7.02E+00
PRF Resin	lb	2.79E+00	kg	4.15E+00
Purchased				
Laminated Veneer Lumber	lb	1.18E+03	kg	1.76E+03
Oriented Strand Board	lb	1.36E+03	kg	2.02E+03
	I-joist Production,SE			
Electrical Use				
Electricity	kWh	6.87E+01	MJ	8.12E+02
Fuel Use				
Liquid propane gas	Btu	3.18E+04	MJ	1.10E+02
Natural gas	Btu	5.59E+04	MJ	1.93E+02
Diesel	Btu	3.78E+04	MJ	1.31E+02
Water Usage				
Municipal Water Source	lbs	4.73E+01	kg	7.04E+01
Recycled Water	lbs	2.10E+00	kg	3.12E+00
Well Water Source	lbs	3.10E+00	kg	4.61E+00
	PF (PRF) Resin Production			
Electrical Use				
Electricity	kWh	1.79E+00	MJ	2.12E+01
Fuel Use				
Heavy oil	Btu	1.74E+03	MJ	6.02E+00
Natural gas	Btu	1.20E+01	MJ	4.15E-02
Diesel	Btu	3.23E+04	MJ	1.12E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	1.83E+04	MJ	6.32E+01
Energy from oil	Btu	4.89E+04	MJ	1.69E+02
Energy from natural gas	Btu	1.17E+05	MJ	4.06E+02
Energy from hydro power	Btu	1.04E+03	MJ	3.59E+00
Energy from uranium	Btu	1.12E+04	MJ	3.88E+01
Energy from lignite	Btu	3.13E+03	MJ	1.08E+01
Energy from biomass	Btu	8.13E+01	MJ	2.81E-01
Energy from hydrogen	Btu	1.97E+03	MJ	6.82E+00
Energy (undef.)	Btu	2.03E+02	MJ	7.03E-01
Energy from peat	Btu	6.09E+00	MJ	2.11E-02
Energy from sulphur	Btu	8.73E+01	MJ	3.02E-01
Energy from wood	Btu	7.31E+00	MJ	2.53E-02
Energy recovered	Btu	-9.40E+03	MJ	-3.25E+01

LCI Outputs

Product

Substance	**lb per MLF**	**kg per 10^3m^3**
Composite I-joists	2.37E+03	3.52E+03

Co-products

Substance	**lb per MLF**	**kg per 10^3m^3**
Sawdust	1.78E+02	2.65E+02

Raw Materials

Substance	**lb per MLF**	**kg per 10^3m^3**
SE Bark on Logs	5.00E+01	7.50E+01
SE Logs	9.99E+02	1.49E+03

Substance	**lb per MLF**	**kg per 10^3m^3**
Air	5.06E+00	7.52E+00
Baryte	2.19E-03	3.26E-03
Bauxite	2.58E-03	3.84E-03
Bentonite	1.19E-03	1.77E-03
Calcium sulphate	1.18E-04	1.76E-04
Chalk	1.40E-28	2.08E-28
Chromium (in ore)	8.43E-12	1.25E-11
Clay minerals	1.32E-04	1.96E-04
Coal FAL	2.01E+02	3.00E+02
Crude oil FAL	8.69E+01	1.29E+02
Dolomite	5.20E-04	7.74E-04
Feldspar	1.77E-34	2.63E-34
Ferromanganese	7.16E-06	1.06E-05
Fluorspar	3.87E-05	5.76E-05
Granite	2.88E-07	4.28E-07
Gravel	2.68E-05	3.98E-05
Iron (in ore)	8.36E-03	1.24E-02
KCl	1.54E-01	2.30E-01
Lead (in ore)	2.19E-05	3.26E-05
Limestone	1.43E+01	2.13E+01
NaCl	5.66E+00	8.43E+00
Natural gas FAL	1.98E+02	2.95E+02
Nickel (in ore)	1.32E-06	1.96E-06
Nitrogen	1.52E+00	2.27E+00
Olivine	7.16E-05	1.06E-04
Oxygen	1.81E+00	2.69E+00
Phosphate (as P2O5)	8.69E-05	1.29E-04
Rutile	2.01E-28	2.99E-28
Sand	9.90E-03	1.47E-02
Shale	3.34E-04	4.98E-04
Southeast Bark	1.26E+02	1.88E+02

Electricity

Substance	**Btu per MLF**	**MJ per 10^3m^3**
Electricity	7.77E+01	2.69E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	4.71E+04	1.63E+02
Energy (undef.)	5.15E+02	1.78E+00
Energy from biomass	1.97E+02	6.81E-01
Energy from coal	4.64E+04	1.61E+02
Energy from hydro power	3.11E+04	1.08E+02
Energy from hydrogen	5.00E+03	1.73E+01
Energy from lignite	7.96E+03	2.75E+01
Energy from natural gas	2.99E+05	1.03E+03
Energy from oil	1.24E+05	4.30E+02
Energy from peat	1.69E+01	5.85E-02
Energy from sulphur	2.34E+02	8.11E-01
Energy from uranium	2.85E+04	9.85E+01
Energy from wood	1.87E+01	6.48E-02
Energy recovered	-2.39E+04	-8.26E+01

Water Usage-- at Manufacturing Facility

Substance	**lbs per MLF**	**kg per 10^3m^3**
Municipal Water Source	5.41E+02	8.04E+02
Recycled Water	2.19E+01	3.26E+01
Well Water Source	4.05E+02	6.03E+02

Air Emissions

Substance	**lb per MLF**	**kg per 10^3m^3**
1,2-dichloroethane	3.12E-10	4.65E-10
Acetaldehyde	1.24E-01	1.84E-01
Acetone	2.39E-02	3.56E-02
Acrolein	4.40E-02	6.55E-02
Aldehydes	5.90E-03	8.78E-03
Ammonia	3.94E-03	5.86E-03
As	3.99E-05	5.94E-05
Ash	1.67E-04	2.49E-04
Ba	7.42E-04	1.10E-03
Be	2.38E-06	3.54E-06
Benzene	6.55E-04	9.75E-04
Cd	1.87E-05	2.78E-05
CFC (soft)	3.48E-05	5.17E-05
Cl_2	1.34E-03	1.99E-03
CO	6.11E+00	9.10E+00
CO_2	5.26E+01	7.83E+01
CO_2 (biomass)	1.09E+03	1.62E+03
CO_2 (fossil)	8.96E+02	1.33E+03
CO_2 (non-fossil)	4.56E+01	6.79E+01

Southeast Hardwood Logs	3.99E+02	5.93E+02
Southeast Softwood Logs	1.20E+03	1.78E+03
Sulphur (bonded)	2.94E-02	4.37E-02
Sulphur (elemental)	5.89E-02	8.77E-02
Uranium FAL	1.02E-03	1.51E-03
Water	9.83E+01	1.46E+02
Water (cooling)	2.15E+02	3.19E+02
Water (drinking, for process.)	9.83E+02	1.46E+03
Water (process)	7.22E+00	1.07E+01
Water (sea, for cooling)	1.24E+03	1.85E+03
Water (sea, for processing)	4.46E+00	6.64E+00
Water (surface, for cooling)	1.86E+03	2.77E+03
Water (surface, for process.)	1.33E+01	1.98E+01
Water (well, for cooling)	5.90E-02	8.78E-02
Water (well, for processing)	4.33E-01	6.44E-01
Wood/wood wastes FAL	4.36E+01	6.49E+01
Zinc (in ore)	6.89E-07	1.02E-06

Other Raw Materials

Substance	Btu per MLF	MJ per 10^3m^3
Heat from DFO	1.03E+04	3.55E+01
Heat from Natural Gas	2.59E+04	8.96E+01
Hogged Fuel Direct Fired	2.34E+06	8.11E+03

Air Emissions-cont.

Substance	lb per MLF	kg per 10^3m^3
CS_2	3.00E-09	4.46E-09
Cumene	3.54E-04	5.27E-04
C_xH_y	4.79E-02	7.13E-02
C_xH_y aromatic	8.69E-04	1.29E-03
C_xH_y chloro	1.46E-04	2.17E-04
Dichloromethane	2.92E-05	4.34E-05
Dioxin (TEQ)	3.83E-11	5.69E-11
Dust	5.68E-02	8.46E-02
F_2	3.30E-08	4.92E-08
Fe	7.42E-04	1.10E-03
Formaldehyde	1.93E-01	2.87E-01
H_2	2.16E-02	3.21E-02
H_2S	6.21E-06	9.24E-06
H_2SO_4	1.91E-04	2.85E-04
HCl	3.79E-02	5.63E-02
HCN	6.89E-34	1.02E-33
HF	5.10E-03	7.58E-03
Hg	2.08E-05	3.09E-05
K	1.31E-01	1.95E-01
Kerosene	2.24E-04	3.33E-04
MDI (isocyanate)	1.50E-04	2.23E-04
Mercaptans	8.69E-07	1.29E-06
Cobalt	2.11E-05	3.13E-05
Cr	3.88E-05	5.77E-05

Water Emissions

Substance	lb per MLF	kg per 10^3m^3
Acid as H+	9.56E-04	1.42E-03
Al	1.01E-04	1.50E-04
As	3.36E-09	5.00E-09
B	2.01E-02	3.00E-02
BOD	2.03E-02	3.02E-02
Ca	5.16E-07	7.68E-07
Calcium ions	1.54E-03	2.30E-03
Carbonate	1.77E-03	2.64E-03
Cd	4.77E-04	7.11E-04
Chromate	1.46E-05	2.17E-05
Cl-	2.19E+00	3.26E+00
Cl_2	1.34E-04	2.00E-04
COD	1.61E-01	2.40E-01
Cr	4.77E-04	7.11E-04
Cu	1.94E-06	2.89E-06
C_xH_y	4.69E-04	6.98E-04
C_xH_y chloro	3.96E-05	5.89E-05
Cyanide	8.76E-07	1.30E-06
Detergent/oil	4.66E-04	6.94E-04
Dissolved organics	4.25E-03	6.33E-03
Dissolved solids	1.06E+01	1.57E+01
Fe	2.82E-02	4.19E-02
Fluoride ions	8.96E-04	1.33E-03
H_2SO_4	5.04E-03	7.49E-03
Hg	3.90E-06	5.80E-06
K	4.43E-03	6.60E-03
Metallic ions	4.37E-03	6.50E-03
Mg	1.76E-04	2.62E-04
Mn	1.58E-02	2.35E-02
N-tot	7.62E-04	1.13E-03
Na	1.15E+00	1.71E+00
NH_3	5.26E-04	7.83E-04
NH_4+	2.45E-03	3.65E-03
Ni	9.16E-05	1.36E-04
Nitrate	1.93E-03	2.88E-03
Oil	1.87E-01	2.78E-01
Other organics	3.58E-02	5.32E-02
P_2O_5	1.14E-04	1.69E-04
Pb	1.38E-07	2.06E-07
Phenol	6.30E-05	9.37E-05
Phosphate	2.51E-03	3.74E-03
Sulphate	5.58E-01	8.31E-01
Sulphur/sulphide	8.36E-06	1.24E-05
Suspended solids	4.15E-01	6.17E-01

Metals	2.15E-04	3.20E-04
Methane	2.44E+00	3.63E+00
Methanol	4.76E-01	7.09E-01
Mn	1.57E-03	2.34E-03
N-nitrodimethylamine	8.76E-03	1.30E-02
N_2O	4.23E-03	6.30E-03
Na	3.03E-03	4.51E-03
Naphthalene	4.05E-04	6.02E-04
Ni	3.50E-04	5.21E-04
Non methane VOC	2.76E+00	4.10E+00
NO_x	5.63E+00	8.38E+00
Organic substances	3.54E-02	5.27E-02
Particulates	7.16E-01	1.06E+00
Particulates (PM10)	1.02E+00	1.52E+00
Particulates (unspecified)	5.15E-01	7.66E-01
Pb	2.34E-04	3.48E-04
Phenol	1.34E-01	1.99E-01
Sb	8.23E-06	1.22E-05
Se	5.72E-05	8.52E-05
SO_2	2.24E-01	3.33E-01
SO_x	1.01E+01	1.50E+01
Tetrachloroethene	7.02E-06	1.04E-05
Tetrachloromethane	1.90E-05	2.83E-05
Trichloroethene	6.82E-06	1.02E-05
Vinyl chloride	3.12E-10	4.64E-10
VOC	2.11E+00	3.14E+00
Water vapor	4.76E+02	7.09E+02
Zn	7.42E-04	1.10E-03

Vinyl chloride	2.61E-31	3.89E-31
Zn	7.82E-04	1.16E-03

Solid Waste Emission

Substance	lb per MLF	kg per $10^3 m^3$
Boiler ash	3.95E+00	5.88E+00
Chemical waste (inert)	3.41E-02	5.08E-02
Chemical waste (regulated)	5.60E-02	8.34E-02
Construction waste	9.43E-04	1.40E-03
Industrial waste	1.26E-01	1.88E-01
Metal scrap	1.77E-04	2.64E-04
Mineral waste	1.01E+00	1.50E+00
Paper/board packaging	5.85E-05	8.71E-05
Plastics packaging	1.95E-03	2.91E-03
Slags/ash	2.49E-01	3.70E-01
Solid waste	1.25E+02	1.86E+02
Special waste	5.06E-03	7.53E-03
Unspecified	1.43E-04	2.13E-04
Waste in incineration	2.00E-02	2.98E-02
Waste to recycling	4.41E-03	6.56E-03
Wood packaging	9.56E-05	1.42E-04
Wood waste	4.27E-01	6.35E-01

Nonmaterial Emission

Substance	bq per MLF	bq per $10^3 m^3$
Radioactive sub. to air	4.98E+06	7.40E+06

Table A1.6. LCI data for 1.0 MLF of I-joists in the SEwith the dimensions of 11.875" in depth with flange dimensions of 1.5"x 1.75".

LCI Inputs				
SE I-joist -INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per 10^3m^3**
MDI (isocyanate) Resin	lb	5.09E+00	kg	7.57E+00
PRF Resin	lb	3.00E+00	kg	4.46E+00
Purchased				
Laminated Veneer Lumber	lb	2.55E+03	kg	3.80E+03
Oriented Strand Board	lb	1.92E+02	kg	2.86E+02
	I-joist Production, SE			
Electrical Use				
Electricity	kWh	7.41E+01	MJ	8.75E+02
Fuel Use				
Liquid propane gas	Btu	3.43E+04	MJ	1.19E+02
Natural gas	Btu	6.34E+04	MJ	2.19E+02
Diesel	Btu	4.07E+04	MJ	1.41E+02
Water Usage				
Municipal Water Source	lbs	5.10E+01	kg	7.59E+01
Recycled Water	lbs	2.30E+00	kg	3.42E+00
Well Water Source	lbs	3.30E+00	kg	4.91E+00
	PF (PRF) Resin Production			
Electrical Use				
Electricity	kWh	1.93E+00	MJ	2.27E+01
Fuel Use				
Heavy oil	Btu	1.87E+03	MJ	6.48E+00
Natural gas	Btu	1.29E+01	MJ	4.46E-02
Diesel	Btu	3.48E+04	MJ	1.20E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	1.97E+04	MJ	6.82E+01
Energy from oil	Btu	5.27E+04	MJ	1.82E+02
Energy from natural gas	Btu	1.27E+05	MJ	4.38E+02
Energy from hydro power	Btu	1.12E+03	MJ	3.87E+00
Energy from uranium	Btu	1.21E+04	MJ	4.18E+01
Energy from lignite	Btu	3.37E+03	MJ	1.17E+01
Energy from biomass	Btu	8.77E+01	MJ	3.03E-01
Energy from hydrogen	Btu	2.12E+03	MJ	7.35E+00
Energy (undef.)	Btu	2.19E+02	MJ	7.58E-01

Energy from peat	Btu	6.57E+00	MJ	2.27E-02
Energy from sulphur	Btu	9.42E+01	MJ	3.26E-01
Energy from wood	Btu	7.88E+00	MJ	2.73E-02
Energy recovered	Btu	-1.01E+04	MJ	-3.51E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.55E+03	3.80E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	1.92E+02	2.86E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
SE Bark on Logs	5.90E+01	8.70E+01
SE Logs	1.17E+03	1.74E+03

Substance	lb per MLF	kg per 10^3m^3
Air	5.23E+00	7.79E+00
Baryte	2.27E-03	3.38E-03
Bauxite	2.68E-03	3.98E-03
Bentonite	1.23E-03	1.82E-03
Calcium sulphate	1.23E-04	1.82E-04
Chalk	1.44E-28	2.15E-28
Chromium (in ore)	8.70E-12	1.29E-11
Clay minerals	1.36E-04	2.03E-04
Coal FAL	2.15E+02	3.20E+02
Crude oil FAL	9.14E+01	1.36E+02
Dolomite	5.38E-04	8.00E-04
Feldspar	1.83E-34	2.72E-34
Ferromanganese	7.40E-06	1.10E-05
Fluorspar	4.00E-05	5.95E-05
Granite	2.97E-07	4.42E-07
Gravel	2.76E-05	4.11E-05
Iron (in ore)	8.70E-03	1.29E-02
KCl	1.60E-01	2.38E-01
Lead (in ore)	2.27E-05	3.38E-05
Limestone	1.56E+01	2.32E+01
NaCl	5.86E+00	8.72E+00
Natural gas FAL	2.12E+02	3.16E+02
Nickel (in ore)	1.36E-06	2.03E-06
Nitrogen	1.58E+00	2.35E+00

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	7.81E+01	2.70E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	5.05E+04	1.75E+02
Energy (undef.)	5.32E+02	1.84E+00
Energy from biomass	2.04E+02	7.07E-01
Energy from coal	4.80E+04	1.66E+02
Energy from hydro power	3.34E+04	1.16E+02
Energy from hydrogen	5.17E+03	1.79E+01
Energy from lignite	8.24E+03	2.85E+01
Energy from natural gas	3.09E+05	1.07E+03
Energy from oil	1.29E+05	4.46E+02
Energy from peat	1.74E+01	6.02E-02
Energy from sulphur	2.42E+02	8.39E-01
Energy from uranium	2.95E+04	1.02E+02
Energy from wood	1.94E+01	6.70E-02
Energy recovered	-2.47E+04	-8.55E+01

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	6.03E+02	8.97E+02
Recycled Water	2.45E+01	3.65E+01
Well Water Source	4.73E+02	7.04E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	3.23E-10	4.81E-10
Acetaldehyde	1.24E-01	1.84E-01
Acetone	2.81E-02	4.17E-02
Acrolein	4.43E-02	6.59E-02
Aldehydes	6.28E-03	9.34E-03
Ammonia	4.20E-03	6.25E-03
As	4.42E-05	6.58E-05
Ash	1.68E-04	2.50E-04
Ba	8.70E-04	1.29E-03
Be	2.55E-06	3.80E-06
Benzene	7.61E-04	1.13E-03
Cd	1.99E-05	2.97E-05

Olivine	7.40E-05	1.10E-04
Oxygen	1.86E+00	2.77E+00
Phosphate (as P2O5)	8.99E-05	1.34E-04
Rutile	2.07E-28	3.09E-28
Sand	1.02E-02	1.52E-02
Shale	3.47E-04	5.16E-04
Southeast Bark	1.27E+02	1.89E+02
Southeast Hardwood Logs	4.01E+02	5.97E+02
Southeast Softwood Logs	1.20E+03	1.79E+03
Sulphur (bonded)	3.04E-02	4.52E-02
Sulphur (elemental)	6.10E-02	9.07E-02
Uranium FAL	1.09E-03	1.62E-03
Water	9.86E+01	1.47E+02
Water (cooling)	2.22E+02	3.30E+02
Water (drinking, for process.)	1.02E+03	1.52E+03
Water (process)	7.47E+00	1.11E+01
Water (sea, for cooling)	1.29E+03	1.92E+03
Water (sea, for processing)	4.62E+00	6.87E+00
Water (surface, for cooling)	1.92E+03	2.86E+03
Water (surface, for process.)	1.38E+01	2.05E+01
Water (well, for cooling)	6.10E-02	9.08E-02
Water (well, for processing)	4.48E-01	6.67E-01
Wood/wood wastes FAL	5.12E+01	7.62E+01
Zinc (in ore)	7.10E-07	1.06E-06

Other Raw Materials

Substance	Btu per MLF	MJ per $10^3 m^3$
Heat from DFO	1.03E+04	3.57E+01
Heat from Natural Gas	2.61E+04	9.03E+01
Hogged Fuel Direct Fired	2.37E+06	8.19E+03

Air Emissions-cont.

Substance	lb per MLF	kg per $10^3 m^3$
CS_2	3.10E-09	4.61E-09
Cumene	3.76E-04	5.59E-04
C_xH_y	4.96E-02	7.38E-02
C_xH_y aromatic	8.99E-04	1.34E-03
C_xH_y chloro	1.51E-04	2.24E-04
Dichloromethane	3.12E-05	4.65E-05
Dioxin (TEQ)	4.10E-11	6.10E-11
Dust	5.89E-02	8.76E-02
F_2	3.41E-08	5.08E-08
Fe	8.70E-04	1.29E-03
Formaldehyde	1.99E-01	2.96E-01
H_2	2.24E-02	3.33E-02
H_2S	6.43E-06	9.57E-06
H_2SO_4	1.98E-04	2.95E-04
HCl	4.05E-02	6.02E-02
CFC (soft)	3.60E-05	5.35E-05
Cl_2	1.57E-03	2.33E-03
CO	6.65E+00	9.89E+00
CO_2	5.41E+01	8.05E+01
CO_2 (biomass)	1.15E+03	1.70E+03
CO_2 (fossil)	9.57E+02	1.42E+03
CO_2 (non-fossil)	5.35E+01	7.96E+01
Cobalt	2.25E-05	3.36E-05
Cr	4.23E-05	6.30E-05

Water Emissions

Substance	lb per MLF	kg per $10^3 m^3$
Acid as H+	9.79E-04	1.46E-03
Al	1.04E-04	1.55E-04
As	3.47E-09	5.17E-09
B	2.16E-02	3.21E-02
BOD	2.14E-02	3.18E-02
Ca	5.45E-07	8.11E-07
Calcium ions	1.60E-03	2.38E-03
Carbonate	1.83E-03	2.73E-03
Cd	5.13E-04	7.63E-04
Chromate	1.56E-05	2.32E-05
Cl-	2.28E+00	3.40E+00
Cl_2	1.38E-04	2.06E-04
COD	1.70E-01	2.54E-01
Cr	5.13E-04	7.63E-04
Cu	2.01E-06	2.99E-06
C_xH_y	4.85E-04	7.22E-04
C_xH_y chloro	4.10E-05	6.10E-05
Cyanide	9.35E-07	1.39E-06
Detergent/oil	4.83E-04	7.18E-04
Dissolved organics	4.39E-03	6.54E-03
Dissolved solids	1.13E+01	1.68E+01
Fe	3.02E-02	4.49E-02
Fluoride ions	9.57E-04	1.42E-03
H_2SO_4	5.39E-03	8.03E-03
Hg	4.04E-06	6.01E-06
K	4.59E-03	6.83E-03
Metallic ions	4.56E-03	6.79E-03
Mg	1.82E-04	2.71E-04
Mn	1.69E-02	2.51E-02
N-tot	7.90E-04	1.18E-03
Na	1.19E+00	1.77E+00
NH_3	5.63E-04	8.37E-04
NH_4+	2.54E-03	3.79E-03
Ni	9.50E-05	1.41E-04
Nitrate	2.00E-03	2.98E-03
Oil	2.01E-01	2.99E-01
Other organics	3.83E-02	5.70E-02

HCN	7.09E-34	1.06E-33
HF	5.46E-03	8.12E-03
Hg	2.21E-05	3.29E-05
K	1.54E-01	2.30E-01
Kerosene	2.40E-04	3.57E-04
MDI (isocyanate)	1.51E-04	2.24E-04
Mercaptans	8.99E-07	1.34E-06
Metals	2.27E-04	3.38E-04
Methane	2.61E+00	3.88E+00
Methanol	4.94E-01	7.36E-01
Mn	1.84E-03	2.74E-03
N-nitrodimethylamine	8.77E-03	1.31E-02
N_2O	4.54E-03	6.75E-03
Na	3.56E-03	5.30E-03
Naphthalene	4.75E-04	7.07E-04
Ni	3.85E-04	5.73E-04
Non methane VOC	2.95E+00	4.39E+00
NO_x	6.02E+00	8.96E+00
Organic substances	4.07E-02	6.06E-02
Particulates	7.40E-01	1.10E+00
Particulates (PM10)	1.19E+00	1.77E+00
Particulates (unspecified)	5.52E-01	8.22E-01
Pb	2.71E-04	4.03E-04
Phenol	1.41E-01	2.09E-01
Sb	8.85E-06	1.32E-05
Se	6.13E-05	9.13E-05
SO_2	2.25E-01	3.36E-01
SO_x	1.09E+01	1.62E+01
Tetrachloroethene	7.54E-06	1.12E-05
Tetrachloromethane	2.04E-05	3.03E-05
Trichloroethene	7.32E-06	1.09E-05
Vinyl chloride	3.23E-10	4.80E-10
VOC	2.14E+00	3.18E+00
Water vapor	5.59E+02	8.32E+02
Zn	8.70E-04	1.29E-03

P_2O_5	1.17E-04	1.75E-04
Pb	1.46E-07	2.18E-07
Phenol	6.53E-05	9.72E-05
Phosphate	2.70E-03	4.01E-03
Sulphate	5.97E-01	8.88E-01
Sulphur/sulphide	8.70E-06	1.29E-05
Suspended solids	4.43E-01	6.59E-01
Vinyl chloride	2.70E-31	4.02E-31
Zn	8.12E-04	1.21E-03

Solid Waste Emission

Substance	lb per MLF	kg per 10^3m^3
Boiler ash	3.97E+00	5.91E+00
Chemical waste (inert)	3.53E-02	5.25E-02
Chemical waste (regulated)	5.79E-02	8.62E-02
Construction waste	9.72E-04	1.45E-03
Industrial waste	1.31E-01	1.94E-01
Metal scrap	1.83E-04	2.73E-04
Mineral waste	1.04E+00	1.55E+00
Paper/board packaging	6.05E-05	9.01E-05
Plastics packaging	2.02E-03	3.00E-03
Slags/ash	2.57E-01	3.83E-01
Solid waste	1.36E+02	2.02E+02
Special waste	5.09E-03	7.57E-03
Unspecified	1.48E-04	2.20E-04
Waste in incineration	2.07E-02	3.07E-02
Waste to recycling	4.56E-03	6.79E-03
Wood packaging	9.86E-05	1.47E-04
Wood waste	4.29E-01	6.39E-01

Nonmaterial Emission

Substance	bq per MLF	bq per 10^3m^3
Radioactive sub. to air	5.32E+06	7.92E+06

APPENDIX 2: FULL LCI SCENARIO ANALYSES

Full LCI listing for scenario analyses as listed in chapter 2 of the report.

LCI data for the scenario in lumber and plywood were substitutes for LVL and OSB as inputs for manufacturing composite I-joists. Included in the LCI data are the inputs to manufacture the I-joists and the output values as a result of making the composite product. The inputs of lumber and plywood were substituted on a volume basis and not a mass basis. This meant that the new I-joists were lighter than the traditional LVL and OSB I-joists. All other input materials were kept constant in order to be consistent for the analysis.

Table A2.1. Pacific Northwest LCI data for the scenario analyses in which LVL and OSB are replaced by softwood lumber and softwood plywood respectively.

LCI Inputs

PNW I-joist -INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per $10^3 m^3$**
MDI (isocyanate) Resin	lb	1.22E+01	kg	1.82E+01
Purchased				
Softwood Lumber	lb	1.05E+03	kg	1.56E+03
Softwood Plywood	lb	8.67E+02	kg	1.29E+03
	I-joist Production, PNW			
Electrical Use				
Electricity	kWh	8.41E+01	MJ	9.94E+02
Fuel Use				
Liquid propane gas	Btu	1.51E+04	MJ	5.22E+01
Natural gas	Btu	5.02E+03	MJ	1.74E+01
Diesel	Btu	1.14E+04	MJ	3.95E+01
Water Usage				
Municipal Water Source	lbs	1.42E+02	kg	2.11E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	4.74E+04	MJ	1.64E+02
Energy from oil	Btu	1.27E+05	MJ	4.38E+02
Energy from natural gas	Btu	3.04E+05	MJ	1.05E+03
Energy from hydro power	Btu	2.69E+03	MJ	9.29E+00
Energy from uranium	Btu	2.90E+04	MJ	1.00E+02
Energy from lignite	Btu	8.10E+03	MJ	2.80E+01
Energy from biomass	Btu	2.11E+02	MJ	7.29E-01
Energy from hydrogen	Btu	5.10E+03	MJ	1.77E+01
Energy (undefined)	Btu	5.26E+02	MJ	1.82E+00
Energy from peat	Btu	1.58E+01	MJ	5.46E-02
Energy from sulphur	Btu	2.26E+02	MJ	7.83E-01
Energy from wood	Btu	1.89E+01	MJ	6.55E-02
Energy recovered	Btu	-2.44E+04	MJ	-8.43E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.18E+03	3.25E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	2.48E+02	3.69E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
PNW Bark on Logs	3.06E+01	4.56E+01
PNW Logs	6.09E+02	9.06E+02

Substance	lb per MLF	kg per 10^3m^3
Air	3.65E+00	5.43E+00
Baryte	1.58E-03	2.35E-03
Bauxite	1.86E-03	2.77E-03
Bentonite	8.59E-04	1.28E-03
Calcium sulphate	8.54E-05	1.27E-04
Chalk	1.01E-28	1.50E-28
Chromium (in ore)	6.05E-12	9.01E-12
Clay minerals	9.52E-05	1.42E-04
Coal FAL	1.98E+01	2.95E+01
Crude oil (feedstock) FAL	1.87E-02	2.79E-02
Crude oil FAL	1.27E+01	1.89E+01
Dolomite	3.75E-04	5.59E-04
Feldspar	1.28E-34	1.90E-34
Ferromanganese	5.17E-06	7.70E-06
Fluorspar	2.80E-05	4.16E-05
Granite	2.07E-07	3.09E-07
Gravel	1.93E-05	2.87E-05
Iron (in ore)	6.05E-03	9.01E-03
Iron (ore)	2.19E-01	3.26E-01
KCl	1.12E-01	1.66E-01
Lead (in ore)	1.58E-05	2.35E-05
Limestone	2.05E+00	3.05E+00
Logs, PNW	1.17E+03	1.73E+03
Na_2SO_4	1.09E-04	1.62E-04
NaCl	4.09E+00	6.09E+00
Natural gas (feedstock) FAL	5.71E-02	8.50E-02
Natural gas FAL	8.79E+01	1.31E+02
Nickel (in ore)	9.52E-07	1.42E-06
Nitrogen	1.10E+00	1.64E+00
Olivine	5.17E-05	7.70E-05

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr oth sources	4.74E+03	1.64E+01
Energy (undef.)	3.38E+03	1.17E+01
Energy from biomass	1.42E+02	4.92E-01
Energy from coal	3.35E+04	1.16E+02
Energy from hydro power	5.26E+05	1.82E+03
Energy from hydrogen	3.61E+03	1.25E+01
Energy from lignite	5.75E+03	1.99E+01
Energy from natural gas	2.16E+05	7.46E+02
Energy from oil	8.98E+04	3.11E+02
Energy from peat	1.22E+01	4.22E-02
Energy from sulphur	1.69E+02	5.86E-01
Energy from uranium	2.05E+04	7.11E+01
Energy from wood	1.35E+01	4.68E-02
Energy recovered	-1.73E+04	-5.97E+01

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	3.38E+02	5.03E+02
Recycled Water	9.44E-01	1.41E+00
Well Water Source	8.43E+01	1.25E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	2.26E-10	3.36E-10
Acetaldehyde	9.13E-03	1.36E-02
Acetone	3.45E-03	5.14E-03
Acrolein	2.25E-06	3.35E-06
Aldehydes	1.78E-03	2.64E-03
Alpha-pinene	5.08E-02	7.55E-02
Ammonia	1.29E-03	1.92E-03
As	2.55E-05	3.79E-05
Ba	1.17E-03	1.74E-03
Be	2.15E-07	3.20E-07
Benzene	9.62E-04	1.43E-03
Beta-pinene	1.96E-02	2.91E-02
Cd	1.21E-06	1.80E-06
CFC (soft)	2.51E-05	3.73E-05
Cl_2	2.08E-03	3.09E-03
CO	4.32E+00	6.44E+00
CO_2	2.94E+01	4.37E+01
CO_2 (biomass)	5.52E+02	8.21E+02

Oxygen	1.32E+00	1.96E+00
Pesticides	5.96E-08	8.86E-08
Phosphate (as P2O5)	6.25E-05	9.30E-05
Phosphate (ore)	5.66E-06	8.43E-06
Rutile	1.45E-28	2.16E-28
Sand	7.13E-03	1.06E-02
Scrap, external	7.71E-02	1.15E-01
Seed corn	3.19E-07	4.74E-07
Shale	2.42E-04	3.60E-04
Silica	6.59E-07	9.81E-07
Soda ash	3.52E-05	5.24E-05
Sulphur	5.32E-06	7.92E-06
Sulphur (bonded)	2.12E-02	3.15E-02
Sulphur (elemental)	4.26E-02	6.33E-02
Sylvinite	2.79E-06	4.15E-06
Uranium FAL	1.03E-04	1.53E-04
Water (cooling)	1.55E+02	2.31E+02
Water (drinking, for process.)	7.13E+02	1.06E+03
Water (process)	5.22E+00	7.77E+00
Water (sea, for cooling)	8.98E+02	1.34E+03
Water (sea, for processing)	3.22E+00	4.79E+00
Water (surface, for cooling)	1.44E+03	2.15E+03
Water (surface, for process.)	9.62E+00	1.43E+01
Water (well, for cooling)	1.44E+02	2.15E+02
Water (well, for processing)	3.12E-01	4.65E-01
Wood for fiber (feedstock) FAL	2.37E-02	3.53E-02
Wood/wood wastes FAL	1.23E+01	1.83E+01
Zinc (in ore)	4.93E-07	7.34E-07

Other Raw Materials

Substance	Btu per MLF	MJ per $10^3 m^3$
Hogged Fuel Direct Fired	4.68E+04	1.62E+02

Air Emissions-cont.

Substance	lb per MLF	kg per $10^3 m^3$
C_xH_y chloro	1.05E-04	1.57E-04
Dichloromethane	2.82E-06	4.19E-06
Dioxin (TEQ)	3.76E-12	5.59E-12
Dust	4.11E-02	6.11E-02
Dust (coarse)	2.50E-01	3.72E-01
Dust (PM10)	1.87E-02	2.78E-02
F_2	2.38E-08	3.54E-08
Fe	1.17E-03	1.74E-03
Formaldehyde	2.84E-02	4.23E-02
H_2	1.56E-02	2.32E-02
H_2S	4.49E-06	6.67E-06
H_2SO_4	1.38E-04	2.06E-04
HCl	4.72E-03	7.02E-03
CO_2 (fossil)	2.48E+02	3.69E+02
CO_2 (non-fossil)	1.29E+01	1.92E+01
Cobalt	1.55E-06	2.31E-06
Cr	1.51E-05	2.25E-05
CS_2	2.16E-09	3.22E-09
Cu	2.75E-09	4.10E-09
Cumene	4.87E-05	7.25E-05
C_xH_y	3.46E-02	5.15E-02
C_xH_y aromatic	6.30E-04	9.37E-04

Water Emissions

Substance	lb per MLF	kg per $10^3 m^3$
Acid as H+	3.65E-04	5.43E-04
Acids (unspecified)	9.96E-06	1.48E-05
Al	7.52E-05	1.12E-04
As	2.43E-09	3.61E-09
B	1.89E-03	2.81E-03
BOD	1.17E-02	1.74E-02
Ca	1.13E-07	1.69E-07
Calcium ions	9.96E-04	1.48E-03
Carbonate	1.28E-03	1.90E-03
Cd	2.12E-04	3.15E-04
Chromate	9.27E-07	1.38E-06
Cl-	1.45E+00	2.16E+00
Cl_2	9.66E-05	1.44E-04
COD	1.06E-01	1.58E-01
Cr	2.12E-04	3.15E-04
Cu	1.40E-06	2.08E-06
C_xH_y	3.38E-04	5.03E-04
C_xH_y chloro	2.86E-05	4.26E-05
Cyanide	7.08E-07	1.05E-06
Detergent/oil	3.37E-04	5.01E-04
Dissolved organics	2.86E-03	4.26E-03
Dissolved solids	4.74E+00	7.05E+00
Fe	2.81E-03	4.18E-03
Fluoride ions	8.98E-05	1.34E-04
H_2SO_4	4.73E-04	7.03E-04
Hg	2.80E-06	4.17E-06
K	3.20E-03	4.76E-03
Metallic ions	2.32E-03	3.45E-03
Mg	1.27E-04	1.89E-04
Mn	1.56E-03	2.32E-03
N-tot	5.52E-04	8.21E-04
Na	8.30E-01	1.23E+00
NH_3	1.29E-04	1.92E-04
NH_4+	1.77E-03	2.64E-03
Ni	6.64E-05	9.88E-05
Nitrate	1.34E-03	2.00E-03
Oil	8.20E-02	1.22E-01

HCN	4.93E-34	7.34E-34
HF	5.47E-04	8.13E-04
Hg	4.98E-06	7.41E-06
K	2.07E-01	3.09E-01
Kerosene	2.25E-05	3.35E-05
Limonene	5.66E-03	8.43E-03
Mercaptans	6.30E-07	9.37E-07
Metals	8.69E-05	1.29E-04
Methane	8.20E-01	1.22E+00
Methanol	1.03E-01	1.53E-01
Methyl ethyl ketone	4.49E-04	6.67E-04
Methyl i-butyl ketone	3.66E-04	5.45E-04
Mn	2.40E-03	3.57E-03
N-nitrodimethylamine	1.50E-07	2.23E-07
N_2O	4.65E-04	6.91E-04
Na	4.78E-03	7.12E-03
Naphthalene	6.39E-04	9.51E-04
Ni	1.66E-04	2.47E-04
Non methane VOC	9.91E-01	1.47E+00
NO_x	1.81E+00	2.69E+00
Organic substances	5.61E-02	8.35E-02
Particulates	3.05E-01	4.53E-01
Particulates (PM10)	1.56E-01	2.32E-01
Particulates (unspecified)	5.42E-02	8.06E-02
Pb	3.22E-04	4.79E-04
Phenol	2.71E-02	4.03E-02
Sb	6.20E-07	9.22E-07
Se	5.56E-06	8.28E-06
SO_2	5.42E-04	8.06E-04
SO_x	3.50E+00	5.22E+00
Tetrachloroethene	6.78E-07	1.01E-06
Tetrachloromethane	1.25E-06	1.87E-06
THC as Carbon	1.08E-01	1.61E-01
Total reduced sulfur	4.93E-07	7.34E-07
Trichloroethene	6.69E-07	9.95E-07
Vinyl chloride	2.25E-10	3.35E-10
VOC	6.25E-01	9.30E-01
Zn	1.17E-03	1.74E-03

Organic carbon	1.04E-05	1.55E-05
Other organics	1.50E-02	2.24E-02
P-tot	5.56E-07	8.28E-07
P_2O_5	8.20E-05	1.22E-04
Pb	2.90E-08	4.32E-08
Phenol	4.30E-05	6.39E-05
Phosphate	2.39E-04	3.56E-04
Sulphate	2.30E-01	3.42E-01
Sulphide	6.49E-06	9.66E-06
Sulphur/sulphide	6.05E-06	9.01E-06
Suspended solids	1.21E-01	1.79E-01
Vinyl chloride	1.89E-31	2.81E-31
Zn	5.17E-04	7.70E-04

Solid Waste Emission

Substance	lb per MLF	kg per 10^3m^3
Chemical waste (inert)	2.47E-02	3.67E-02
Chemical waste (regulated)	4.04E-02	6.01E-02
Construction waste	6.78E-04	1.01E-03
Industrial waste	9.13E-02	1.36E-01
Inorganic general	1.60E+00	2.38E+00
Metal scrap	1.28E-04	1.91E-04
Mineral waste	7.27E-01	1.08E+00
Paper/board packaging	1.79E-01	2.67E-01
Plastics packaging	1.41E-03	2.10E-03
Slags/ash	1.80E-01	2.67E-01
Solid waste	2.61E+01	3.89E+01
Unspecified	1.03E-04	1.53E-04
Waste in incineration	1.44E-02	2.14E-02
Waste to recycling	3.18E-03	4.74E-03
Wood	1.62E-02	2.40E-02
Wood packaging	6.88E-05	1.02E-04

Nonmaterial Emission

Substance	bq per MLF	bq per 10^3m^3
Radioactive sub. to air	9.14E+05	1.36E+06

Table A2.2. Southeast LCI data for the scenario analyses in which LVL and OSB are replaced by softwood lumber and softwood plywood respectively.

LCI Inputs

SE I-joist -INPUTS				
Material	**Units**	**per MLF**	**SI Units**	**per $10^3 m^3$**
MDI (isocyanate) Resin	lb	5.20E+00	kg	7.74E+00
PRF Resin	lb	3.05E+00	kg	4.54E+00
Purchased				
Softwood Lumber	lb	1.79E+03	kg	2.67E+03
Softwood Plywood	lb	1.07E+03	kg	1.59E+03
	I-joist Production, SE			
Electrical Use				
Electricity	kWh	7.51E+01	MJ	8.87E+02
Fuel Use				
Liquid propane gas	Btu	3.44E+04	MJ	1.19E+02
Natural gas	Btu	6.50E+04	MJ	2.25E+02
Diesel	Btu	4.14E+04	MJ	1.43E+02
Water Usage				
Municipal Water Source	lbs	4.31E+02	kg	6.41E+02
Recycled Water	lbs	1.92E+01	kg	2.85E+01
Well Water Source	lbs	2.83E+01	kg	4.22E+01
	PF (PRF) Resin Production			
Electrical Use				
Electricity	kWh	1.96E+00	MJ	2.31E+01
Fuel Use				
Heavy oil	Btu	1.90E+03	MJ	6.59E+00
Natural gas	Btu	1.31E+01	MJ	4.54E-02
Diesel	Btu	3.53E+04	MJ	1.22E+02
	MDI (isocyanate) Production			
Energy Use				
Energy from coal	Btu	2.01E+04	MJ	6.97E+01
Energy from oil	Btu	5.39E+04	MJ	1.86E+02
Energy from natural gas	Btu	1.29E+05	MJ	4.48E+02
Energy from hydro power	Btu	1.14E+03	MJ	3.95E+00
Energy from uranium	Btu	1.23E+04	MJ	4.27E+01
Energy from lignite	Btu	3.45E+03	MJ	1.19E+01
Energy from biomass	Btu	8.96E+01	MJ	3.10E-01
Energy from hydrogen	Btu	2.17E+03	MJ	7.51E+00
Energy (undef.)	Btu	2.24E+02	MJ	7.75E-01

Energy from peat	Btu	6.71E+00	MJ	2.32E-02
Energy from sulphur	Btu	9.62E+01	MJ	3.33E-01
Energy from wood	Btu	8.05E+00	MJ	2.79E-02
Energy recovered	Btu	-1.04E+04	MJ	-3.58E+01

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.66E+03	3.95E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	2.00E+02	2.98E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
SE Bark from log	4.61E+01	6.90E+01
SE Logs	9.22E+02	1.37E+03

Substance	lb per MLF	kg per 10^3m^3
Air	2.03E+00	3.03E+00
Baryte	8.81E-04	1.31E-03
Bauxite	1.04E-03	1.55E-03
Bentonite	4.78E-04	7.12E-04
Calcium sulphate	4.76E-05	7.08E-05
Chalk	5.63E-29	8.37E-29
Chromium (in ore)	3.39E-12	5.04E-12
Clay minerals	5.30E-05	7.89E-05
Coal FAL	1.28E+02	1.91E+02
Crude oil FAL	3.06E+01	4.55E+01
Dolomite	2.09E-04	3.12E-04
Feldspar	7.12E-35	1.06E-34
Ferromanganese	2.88E-06	4.28E-06
Fluorspar	1.56E-05	2.32E-05
Granite	1.16E-07	1.73E-07
Gravel	1.08E-05	1.60E-05
Iron (in ore)	3.37E-03	5.02E-03
KCl	6.23E-02	9.27E-02
Lead (in ore)	8.81E-06	1.31E-05
Limestone	1.02E+01	1.52E+01
Logs, SE	1.92E+03	2.85E+03
NaCl	2.28E+00	3.40E+00
Natural gas FAL	7.98E+01	1.19E+02
Nickel (in ore)	5.30E-07	7.89E-07

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr oth sources	1.98E+04	6.84E+01
Energy (undef.)	1.05E+04	3.64E+01
Energy from biomass	7.92E+01	2.74E-01
Energy from coal	1.87E+04	6.46E+01
Energy from hydro power	1.66E+04	5.75E+01
Energy from hydrogen	2.01E+03	6.96E+00
Energy from lignite	3.21E+03	1.11E+01
Energy from natural gas	1.20E+05	4.16E+02
Energy from oil	5.00E+04	1.73E+02
Energy from peat	6.78E+00	2.35E-02
Energy from sulphur	9.44E+01	3.27E-01
Energy from uranium	1.14E+04	3.96E+01
Energy from wood	7.53E+00	2.61E-02
Energy recovered	-9.62E+03	-3.33E+01

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	5.18E+02	7.70E+02
Recycled Water	2.09E+01	3.11E+01
Well Water Source	3.77E+02	5.62E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	1.26E-10	1.87E-10
Acetaldehyde	5.38E-03	8.00E-03
Acetone	5.37E-03	7.99E-03
Acrolein	1.01E-05	1.50E-05
Aldehydes	2.70E-03	4.02E-03
Alpha-pinene	7.91E-02	1.18E-01
Ammonia	2.82E-03	4.19E-03
As	6.42E-05	9.56E-05
Ba	2.52E-03	3.74E-03
Be	1.41E-06	2.10E-06
Benzene	2.08E-03	3.09E-03
Beta-pinene	3.07E-02	4.56E-02
Cd	8.13E-06	1.21E-05

Nitrogen	6.15E-01	9.14E-01
Olivine	2.88E-05	4.29E-05
Oxygen	7.26E-01	1.08E+00
Phosphate (as P_2O_5)	3.49E-05	5.19E-05
Rutile	8.06E-29	1.20E-28
Sand	3.97E-03	5.91E-03
Shale	1.35E-04	2.01E-04
Sulphur (bonded)	1.18E-02	1.76E-02
Sulphur (elemental)	2.37E-02	3.53E-02
Uranium FAL	6.50E-04	9.67E-04
Water (cooling)	8.66E+01	1.29E+02
Water (drkng, for process.)	3.97E+02	5.91E+02
Water (process)	2.91E+00	4.33E+00
Water (sea, for cooling)	5.02E+02	7.46E+02
Water (sea, for processing)	1.79E+00	2.67E+00
Water (surface, for cooling)	7.48E+02	1.11E+03
Water (surface, for process.)	5.37E+00	7.99E+00
Water (well, for cooling)	5.83E+02	8.67E+02
Water (well, for processing)	1.74E-01	2.59E-01
Wood/wood wastes FAL	4.77E+01	7.10E+01
Zinc (in ore)	2.76E-07	4.10E-07

Air Emissions-cont.

Substance	lb per MLF	kg per $10^3 m^3$
Cobalt	1.16E-05	1.73E-05
Cr	4.40E-05	6.54E-05
CS_2	1.21E-09	1.79E-09
Cumene	1.11E-04	1.66E-04
C_xH_y	1.93E-02	2.87E-02
C_xH_y aromatic	3.51E-04	5.22E-04
C_xH_y chloro	5.87E-05	8.74E-05
Dichloromethane	1.97E-05	2.94E-05
Dioxin (TEQ)	2.51E-11	3.73E-11
Dust	2.29E-02	3.41E-02
Dust (PM10)	1.68E+00	2.50E+00
F_2	1.33E-08	1.97E-08
Fe	2.52E-03	3.74E-03
Formaldehyde	3.62E-02	5.39E-02
H_2	8.74E-03	1.30E-02
H_2S	2.50E-06	3.72E-06
H_2SO_4	7.68E-05	1.14E-04
HCl	2.39E-02	3.56E-02
HCN	2.76E-34	4.10E-34
HF	3.25E-03	4.83E-03
Hg	1.16E-05	1.73E-05
K	4.46E-01	6.63E-01
Kerosene	1.43E-04	2.13E-04
Limonene	8.89E-03	1.32E-02
Mercaptans	3.51E-07	5.22E-07
CFC (soft)	1.40E-05	2.08E-05
Cl_2	4.47E-03	6.66E-03
CO	8.59E+00	1.28E+01
CO_2	1.63E+01	2.43E+01
CO_2 (biomass)	1.15E+03	1.71E+03
CO_2 (fossil)	4.72E+02	7.03E+02
CO_2 (non-fossil)	4.99E+01	7.42E+01

Water Emissions

Substance	lb per MLF	kg per $10^3 m^3$
Acid as H+	2.03E-04	3.03E-04
Al	4.07E-05	6.05E-05
As	1.36E-09	2.02E-09
B	1.27E-02	1.88E-02
BOD	8.21E-03	1.22E-02
Ca	1.56E-07	2.32E-07
Calcium ions	6.67E-04	9.93E-04
Carbonate	7.13E-04	1.06E-03
Cd	1.92E-04	2.86E-04
Chromate	8.28E-06	1.23E-05
Cl-	8.81E-01	1.31E+00
Cl_2	5.40E-05	8.04E-05
COD	7.17E-02	1.07E-01
Cr	1.92E-04	2.86E-04
Cu	7.83E-07	1.17E-06
C_xH_y	1.89E-04	2.81E-04
C_xH_y chloro	1.60E-05	2.38E-05
Cyanide	3.53E-07	5.26E-07
Detergent/oil	1.88E-04	2.79E-04
Dissolved organics	1.60E-03	2.38E-03
Dissolved solids	4.27E+00	6.35E+00
Fe	1.79E-02	2.67E-02
Fluoride ions	5.70E-04	8.48E-04
H_2SO_4	3.17E-03	4.72E-03
Hg	1.57E-06	2.33E-06
K	1.78E-03	2.66E-03
Metallic ions	1.82E-03	2.71E-03
Mg	7.09E-05	1.05E-04
Mn	1.01E-02	1.50E-02
N-tot	3.07E-04	4.56E-04
Na	4.64E-01	6.90E-01
NH_3	3.10E-04	4.62E-04
NH_4+	9.87E-04	1.47E-03
Ni	3.69E-05	5.49E-05
Nitrate	7.98E-04	1.19E-03
Oil	7.53E-02	1.12E-01
Other organics	1.53E-02	2.27E-02
P_2O_5	4.56E-05	6.79E-05
Pb	6.06E-08	9.02E-08

Metals	1.05E-04	1.57E-04
Methane	1.21E+00	1.79E+00
Methanol	1.30E-01	1.93E-01
Methyl ethyl ketone	7.01E-04	1.04E-03
Methyl i-butyl ketone	5.72E-04	8.52E-04
Mn	5.18E-03	7.71E-03
N-nitrodimethylamine	9.72E-07	1.45E-06
N_2O	2.69E-03	4.00E-03
Na	1.03E-02	1.54E-02
Naphthalene	1.37E-03	2.04E-03
Ni	4.60E-04	6.85E-04
Non methane VOC	1.14E+00	1.69E+00
NO_x	3.43E+00	5.11E+00
Organic substances	9.87E-02	1.47E-01
Particulates	6.11E-01	9.09E-01
Particulates (PM10)	1.91E-01	2.85E-01
Particulates (unspecified)	3.28E-01	4.87E-01
Pb	7.05E-04	1.05E-03
Phenol	5.68E-02	8.45E-02
Sb	4.13E-06	6.14E-06
Se	3.53E-05	5.26E-05
SO_2	6.67E-05	9.92E-05
SO_x	4.87E+00	7.24E+00
Tetrachloroethene	4.46E-06	6.63E-06
Tetrachloromethane	1.14E-05	1.70E-05
THC as Carbon	1.69E-01	2.52E-01
Trichloroethene	4.36E-06	6.49E-06
Vinyl chloride	1.26E-10	1.87E-10
VOC	1.87E+00	2.78E+00
Water vapor	4.65E+02	6.91E+02
Zn	2.52E-03	3.74E-03

Phenol	2.55E-05	3.80E-05
Phosphate	1.58E-03	2.35E-03
Sulphate	2.52E-01	3.74E-01
Sulphur/sulphide	3.37E-06	5.02E-06
Suspended solids	2.53E-01	3.77E-01
Vinyl chloride	1.05E-31	1.57E-31
Zn	3.15E-04	4.68E-04

Solid Waste Emission

Substance	**lb per MLF**	**kg per 10^3m^3**
Chemical waste (inert)	1.37E-02	2.04E-02
Chemical waste (regulated)	2.25E-02	3.35E-02
Construction waste	3.79E-04	5.64E-04
Industrial waste	5.08E-02	7.56E-02
Metal scrap	7.15E-05	1.06E-04
Mineral waste	4.05E-01	6.03E-01
Paper/board packaging	1.08E+00	1.61E+00
Plastics packaging	7.83E-04	1.17E-03
Slags/ash	1.00E-01	1.49E-01
Solid waste	8.74E+01	1.30E+02
Unspecified	5.75E-05	8.55E-05
Waste in incineration	8.06E-03	1.20E-02
Waste to recycling	1.78E-03	2.64E-03
Wood	7.37E-01	1.10E+00
Wood packaging	3.84E-05	5.72E-05

Nonmaterial Emission

Substance	**bq per MLF**	**bq per 10^3m^3**
Radioactive sub. to air	3.86E+06	5.74E+06

A scenario analysis was completed to compare the LCI outputs as a result of switching fuel source input magnitudes in each region. In the Pacific Northwest, the percentage of hydroelectric power was decreased 10% and natural gas was increased to make up the difference. In the Southeast, the percentage of coal for producing electricity was decreased by 10% and natural gas was increased by 10%. The following tables contain complete LCI listings of the output data for these changes. The LCI input data for composite I-joists will stay the same, so it is not necessary to include that data.

Table A2.3. Pacific Northwest LCI output data for the scenario changes involving fuel input changes for making electricity. The data is for the production of 1.0 MLF of I-joists.

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.02E+03	3.01E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	2.30E+02	3.42E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
PNW Bark on Logs	4.59E+01	6.90E+01
PNW Logs	9.12E+02	1.36E+03

Substance	lb per MLF	kg per 10^3m^3
Air	7.13E+00	1.06E+01
Baryte	3.09E-03	4.60E-03
Bauxite	3.64E-03	5.42E-03
Bentonite	1.68E-03	2.49E-03
Calcium sulphate	1.66E-04	2.48E-04
Chalk	1.97E-28	2.93E-28
Chromium (in ore)	1.19E-11	1.76E-11
Clay minerals	1.86E-04	2.77E-04
Coal FAL	1.04E+02	1.54E+02
Crude oil FAL	7.01E+01	1.04E+02
Dolomite	7.35E-04	1.09E-03
Feldspar	2.49E-34	3.71E-34
Ferromanganese	1.01E-05	1.50E-05
Fluorspar	5.45E-05	8.12E-05
Granite	4.05E-07	6.03E-07
Gravel	3.77E-05	5.61E-05
Iron (in ore)	1.18E-02	1.76E-02
KCl	2.18E-01	3.25E-01
Lead (in ore)	3.09E-05	4.60E-05
Limestone	7.35E+00	1.09E+01
NaCl	7.98E+00	1.19E+01
Natural gas FAL	1.56E+02	2.32E+02
Nickel (in ore)	1.86E-06	2.77E-06
Nitrogen	2.15E+00	3.20E+00
Olivine	1.01E-04	1.50E-04
Oxygen	2.54E+00	3.78E+00
Phosphate (as P2O5)	1.22E-04	1.82E-04

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	6.08E+01	2.11E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	2.77E+04	9.59E+01
Energy (undef.)	7.26E+02	2.51E+00
Energy from biomass	2.77E+02	9.59E-01
Energy from coal	6.55E+04	2.27E+02
Energy from hydro power	5.61E+05	1.94E+03
Energy from hydrogen	7.05E+03	2.44E+01
Energy from lignite	1.12E+04	3.88E+01
Energy from natural gas	4.20E+05	1.45E+03
Energy from oil	1.75E+05	6.06E+02
Energy from peat	2.38E+01	8.24E-02
Energy from sulphur	3.30E+02	1.14E+00
Energy from uranium	4.01E+04	1.39E+02
Energy from wood	2.64E+01	9.12E-02
Energy recovered	-3.37E+04	-1.16E+02

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	5.50E+02	8.18E+02
Recycled Water	1.42E+00	2.11E+00
Well Water Source	1.26E+02	1.88E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	4.41E-10	6.56E-10
Acetaldehyde	1.08E-01	1.61E-01
Acetone	1.12E-02	1.67E-02
Acrolein	3.45E-02	5.13E-02
Aldehydes	4.58E-03	6.81E-03
Alpha-pinene	5.87E-02	8.74E-02
Ammonia	3.44E-03	5.11E-03
As	2.37E-05	3.53E-05
Ash	1.31E-04	1.95E-04
Ba	5.50E-04	8.18E-04
Be	1.20E-06	1.79E-06
Benzene	4.94E-04	7.35E-04
Beta-pinene	2.29E-02	3.40E-02
Cd	9.06E-06	1.35E-05
CFC (soft)	4.90E-05	7.29E-05

Rutile	2.83E-28	4.21E-28
Sand	1.39E-02	2.07E-02
Shale	4.72E-04	7.02E-04
Southeast Bark	9.92E+01	1.48E+02
Southeast Hardwood Logs	3.13E+02	4.66E+02
Southeast Softwood Logs	9.35E+02	1.39E+03
Sulphur (bonded)	4.13E-02	6.15E-02
Sulphur (elemental)	8.32E-02	1.24E-01
Uranium FAL	5.27E-04	7.84E-04
Water	7.70E+01	1.15E+02
Water (cooling)	3.03E+02	4.50E+02
Water (drinking, for process.)	1.39E+03	2.07E+03
Water (process)	1.02E+01	1.52E+01
Water (sea, for cooling)	1.76E+03	2.61E+03
Water (sea, for processing)	6.27E+00	9.33E+00
Water (surface, for cooling)	2.62E+03	3.90E+03
Water (surface, for process.)	1.88E+01	2.80E+01
Water (well, for cooling)	8.32E-02	1.24E-01
Water (well, for processing)	6.10E-01	9.08E-01
Wood/wood wastes FAL	1.78E+01	2.65E+01
Zinc (in ore)	9.69E-07	1.44E-06

Other Raw Materials

Substance	Btu per MLF	MJ per 10^3m^3
Heat from DFO	8.03E+03	2.78E+01
Heat from nat. gas	2.03E+04	7.04E+01
Hogged Fuel Direct Fired	1.92E+06	6.63E+03

Air Emissions-cont.

Substance	lb per MLF	kg per 10^3m^3
Cumene	3.36E-04	5.00E-04
C_xH_y	6.73E-02	1.00E-01
C_xH_y aromatic	1.23E-03	1.82E-03
C_xH_y chloro	2.06E-04	3.06E-04
Dichloromethane	1.50E-05	2.23E-05
Dioxin (TEQ)	1.97E-11	2.93E-11
Dust	8.04E-02	1.20E-01
F_2	4.65E-08	6.92E-08
Fe	5.50E-04	8.18E-04
Formaldehyde	1.80E-01	2.68E-01
H_2	3.05E-02	4.54E-02
H_2S	8.78E-06	1.31E-05
H_2SO_4	2.70E-04	4.01E-04
HCl	2.10E-02	3.12E-02
HCN	9.69E-34	1.44E-33
HF	2.70E-03	4.01E-03
Hg	1.50E-05	2.23E-05
K	9.75E-02	1.45E-01
Cl_2	9.98E-04	1.48E-03
CO	4.70E+00	7.00E+00
CO_2	6.67E+01	9.92E+01
CO_2 (biomass)	8.66E+02	1.29E+03
CO_2 (fossil)	5.76E+02	8.57E+02
CO_2 (non-fossil)	1.86E+01	2.77E+01
Cobalt	1.04E-05	1.54E-05
Cr	2.16E-05	3.21E-05
CS_2	4.22E-09	6.28E-09

Water Emissions

Substance	lb per MLF	kg per 10^3m^3
Acid as H+	1.07E-03	1.59E-03
Al	1.43E-04	2.12E-04
As	4.74E-09	7.05E-09
B	1.03E-02	1.54E-02
BOD	2.21E-02	3.28E-02
Ca	4.86E-07	7.23E-07
Calcium ions	2.01E-03	2.99E-03
Carbonate	2.50E-03	3.71E-03
Cd	3.76E-04	5.59E-04
Chromate	7.01E-06	1.04E-05
Cl-	2.79E+00	4.15E+00
Cl_2	1.89E-04	2.82E-04
COD	1.67E-01	2.49E-01
Cr	3.76E-04	5.59E-04
Cu	2.74E-06	4.07E-06
C_xH_y	6.61E-04	9.84E-04
C_xH_y chloro	5.58E-05	8.30E-05
Cyanide	7.92E-07	1.18E-06
Detergent/oil	6.56E-04	9.75E-04
Dissolved organics	5.81E-03	8.65E-03
Dissolved solids	8.38E+00	1.25E+01
Fe	1.45E-02	2.16E-02
Fluoride ions	4.63E-04	6.89E-04
H_2SO_4	2.58E-03	3.83E-03
Hg	5.47E-06	8.14E-06
K	6.27E-03	9.33E-03
Metallic ions	5.23E-03	7.79E-03
Mg	2.48E-04	3.69E-04
Mn	8.15E-03	1.21E-02
N-tot	1.07E-03	1.59E-03
Na	1.62E+00	2.42E+00
NH_3	3.27E-04	4.87E-04
NH_4+	3.47E-03	5.16E-03
Ni	1.29E-04	1.93E-04
Nitrate	2.64E-03	3.94E-03
Oil	1.47E-01	2.19E-01
Other organics	2.82E-02	4.20E-02

Kerosene	1.16E-04	1.73E-04
Limonene	6.61E-03	9.84E-03
MDI (isocyanate)	1.17E-04	1.75E-04
Mercaptans	1.23E-06	1.83E-06
Metals	2.01E-04	2.99E-04
Methane	1.80E+00	2.68E+00
Methanol	4.33E-01	6.44E-01
Methyl ethyl ketone	5.23E-04	7.79E-04
Methyl I-butyl ketone	4.27E-04	6.35E-04
Mn	1.16E-03	1.72E-03
N-nitrodimethylamine	6.84E-03	1.02E-02
N_2O	2.18E-03	3.24E-03
Na	2.25E-03	3.35E-03
Naphthalene	3.01E-04	4.48E-04
Ni	1.94E-04	2.89E-04
Non methane VOC	2.25E+00	3.35E+00
NO_x	4.15E+00	6.17E+00
Organic substances	2.68E-02	3.99E-02
Particulates	8.49E-01	1.26E+00
Particulates (PM10)	2.81E-01	4.18E-01
Particulates (unspecified)	2.67E-01	3.98E-01
Pb	1.67E-04	2.49E-04
Phenol	1.24E-01	1.85E-01
Propionaldehyde	4.37E-04	6.51E-04
Sb	4.06E-06	6.05E-06
Se	2.96E-05	4.40E-05
SO_2	1.77E-01	2.63E-01
SO_x	7.18E+00	1.07E+01
Tetrachloroethene	3.60E-06	5.36E-06
Tetrachloromethane	9.12E-06	1.36E-05
THC as Carbon	1.27E-01	1.88E-01
Trichloroethene	3.52E-06	5.24E-06
Vinyl chloride	4.39E-10	6.54E-10
VOC	2.21E+00	3.29E+00
Zn	5.51E-04	8.20E-04

P_2O_5	1.60E-04	2.37E-04
Pb	1.16E-07	1.73E-07
Phenol	8.61E-05	1.28E-04
Phosphate	1.29E-03	1.92E-03
Sulphate	4.55E-01	6.77E-01
Sulphur/sulphide	1.18E-05	1.76E-05
Suspended solids	2.59E-01	3.85E-01
Vinyl chloride	3.68E-31	5.48E-31
Zn	9.98E-04	1.48E-03

Solid Waste Emission

Substance	lb per MLF	kg per $10^3 m^3$
Boiler ash	3.10E+00	4.61E+00
Chemical waste (inert)	4.81E-02	7.16E-02
Chemical waste (regulated)	7.87E-02	1.17E-01
Construction waste	1.33E-03	1.98E-03
Industrial waste	1.78E-01	2.65E-01
Metal scrap	2.50E-04	3.72E-04
Mineral waste	1.42E+00	2.11E+00
Paper/board packaging	8.27E-05	1.23E-04
Plastics packaging	2.75E-03	4.09E-03
Slags/ash	3.51E-01	5.22E-01
Solid waste	7.30E+01	1.09E+02
Special waste	3.97E-03	5.90E-03
Unspecified	2.01E-04	2.99E-04
Waste in incineration	2.82E-02	4.19E-02
Waste to recycling	6.21E-03	9.24E-03
Wood packaging	1.35E-04	2.00E-04
Wood waste	3.35E-01	4.98E-01

Nonmaterial Emission

Substance	bq per MLF	bq per $10^3 m^3$
Radioactive sub. to air	3.22E+06	4.79E+06

Table A2.4. Southeast LCI output data for the scenario changes involving fuel input changes for making electricity. The data is for the production of 1.0 MLF of I-joists.

LCI Outputs

Product

Substance	lb per MLF	kg per 10^3m^3
Composite I-joists	2.60E+03	3.88E+03

Co-products

Substance	lb per MLF	kg per 10^3m^3
Sawdust	1.96E+02	2.91E+02

Raw Materials

Substance	lb per MLF	kg per 10^3m^3
SE Bark on Logs	6.80E+01	1.02E+02
SE Logs	1.36E+03	2.03E+03

Substance	lb per MLF	kg per 10^3m^3
Air	4.87E+00	7.24E+00
Baryte	2.11E-03	3.14E-03
Bauxite	2.49E-03	3.71E-03
Bentonite	1.14E-03	1.70E-03
Calcium sulphate	1.14E-04	1.69E-04
Chalk	1.34E-28	2.00E-28
Chromium (in ore)	8.11E-12	1.21E-11
Clay minerals	1.27E-04	1.89E-04
Coal FAL	2.01E+02	2.98E+02
Crude oil FAL	8.78E+01	1.31E+02
Dolomite	5.01E-04	7.45E-04
Feldspar	1.70E-34	2.53E-34
Ferromanganese	6.88E-06	1.02E-05
Fluorspar	3.73E-05	5.55E-05
Granite	2.77E-07	4.12E-07
Gravel	2.57E-05	3.83E-05
Iron (in ore)	8.04E-03	1.20E-02
KCl	1.49E-01	2.22E-01
Lead (in ore)	2.11E-05	3.14E-05
Limestone	1.52E+01	2.26E+01
NaCl	5.46E+00	8.12E+00
Natural gas FAL	2.21E+02	3.29E+02
Nickel (in ore)	1.27E-06	1.89E-06
Nitrogen	1.47E+00	2.18E+00
Olivine	6.90E-05	1.03E-04
Oxygen	1.74E+00	2.59E+00
Phosphate (as P2O5)	8.33E-05	1.24E-04

Electricity

Substance	Btu per MLF	MJ per 10^3m^3
Electricity	6.86E+01	2.37E-01
Electricity from ATHENA	0.00E+00	0.00E+00
Electricity fr. oth. Sources	5.04E+04	1.74E+02
Energy (undef.)	4.97E+02	1.72E+00
Energy from biomass	1.90E+02	6.57E-01
Energy from coal	4.47E+04	1.55E+02
Energy from hydro power	2.87E+04	9.92E+01
Energy from hydrogen	4.81E+03	1.67E+01
Energy from lignite	7.67E+03	2.65E+01
Energy from natural gas	2.88E+05	9.96E+02
Energy from oil	1.19E+05	4.12E+02
Energy from peat	1.63E+01	5.64E-02
Energy from sulphur	2.25E+02	7.80E-01
Energy from uranium	2.74E+04	9.47E+01
Energy from wood	1.81E+01	6.25E-02
Energy recovered	-2.30E+04	-7.96E+01

Water Usage-- at Manufacturing Facility

Substance	lbs per MLF	kg per 10^3m^3
Municipal Water Source	6.39E+02	9.51E+02
Recycled Water	2.56E+01	3.80E+01
Well Water Source	5.45E+02	8.11E+02

Air Emissions

Substance	lb per MLF	kg per 10^3m^3
1,2-dichloroethane	3.01E-10	4.48E-10
Acetaldehyde	1.09E-01	1.62E-01
Acetone	3.26E-02	4.85E-02
Acrolein	3.89E-02	5.78E-02
Aldehydes	6.20E-03	9.22E-03
Ammonia	4.62E-03	6.88E-03
As	4.59E-05	6.84E-05
Ash	1.48E-04	2.19E-04
Ba	1.01E-03	1.50E-03
Be	2.43E-06	3.61E-06
Benzene	8.78E-04	1.31E-03
Cd	1.99E-05	2.96E-05
CFC (soft)	3.35E-05	4.98E-05
Cl_2	1.81E-03	2.70E-03
CO	6.86E+00	1.02E+01

Rutile	1.93E-28	2.88E-28
Sand	9.51E-03	1.42E-02
Shale	3.22E-04	4.80E-04
Southeast Bark	1.11E+02	1.66E+02
Southeast Hardwood Logs	3.52E+02	5.23E+02
Southeast Softwood Logs	1.05E+03	1.57E+03
Sulphur (bonded)	2.82E-02	4.20E-02
Sulphur (elemental)	5.68E-02	8.45E-02
Uranium FAL	1.09E-03	1.62E-03
Water	8.70E+01	1.29E+02
Water (cooling)	2.07E+02	3.08E+02
Water (drinking, for process.)	9.51E+02	1.42E+03
Water (process)	6.95E+00	1.03E+01
Water (sea, for cooling)	1.20E+03	1.79E+03
Water (sea, for processing)	4.30E+00	6.40E+00
Water (surface, for cooling)	1.79E+03	2.67E+03
Water (surface, for process.)	1.28E+01	1.91E+01
Water (well, for cooling)	5.69E-02	8.46E-02
Water (well, for processing)	4.17E-01	6.20E-01
Wood/wood wastes FAL	5.94E+01	8.83E+01
Zinc (in ore)	6.61E-07	9.83E-07

Other Raw Materials

Substance	Btu per MLF	MJ per $10^3 m^3$
Heat from DFO	9.04E+03	3.13E+01
Heat from nat. gas	2.29E+04	7.92E+01
Hogged Fuel Direct Fired	2.08E+06	7.19E+03

Air Emissions-cont.

Substance	lb per MLF	kg per $10^3 m^3$
CS_2	2.88E-09	4.29E-09
Cumene	3.66E-04	5.44E-04
C_xH_y	4.62E-02	6.87E-02
C_xH_y aromatic	8.41E-04	1.25E-03
C_xH_y chloro	1.41E-04	2.10E-04
Dichloromethane	2.91E-05	4.33E-05
Dioxin (TEQ)	3.81E-11	5.67E-11
Dust	5.48E-02	8.15E-02
F_2	3.18E-08	4.73E-08
Fe	1.01E-03	1.50E-03
Formaldehyde	1.85E-01	2.75E-01
H_2	2.09E-02	3.11E-02
H_2S	5.98E-06	8.90E-06
H_2SO_4	1.84E-04	2.74E-04
HCl	3.77E-02	5.61E-02
HCN	6.60E-34	9.82E-34
HF	5.08E-03	7.56E-03
Hg	2.07E-05	3.08E-05
CO_2	4.97E+01	7.40E+01
CO_2 (biomass)	1.11E+03	1.66E+03
CO_2 (fossil)	9.44E+02	1.40E+03
CO_2 (non-fossil)	6.21E+01	9.24E+01
Cobalt	2.22E-05	3.30E-05
Cr	4.26E-05	6.33E-05

Water Emissions

Substance	lb per MLF	kg per $10^3 m^3$
Acid as H+	8.85E-04	1.32E-03
Al	9.74E-05	1.45E-04
As	3.24E-09	4.82E-09
B	2.03E-02	3.02E-02
BOD	2.11E-02	3.14E-02
Ca	5.29E-07	7.87E-07
Calcium ions	1.51E-03	2.25E-03
Carbonate	1.70E-03	2.53E-03
Cd	5.35E-04	7.96E-04
Chromate	1.56E-05	2.32E-05
Cl-	2.18E+00	3.25E+00
Cl_2	1.29E-04	1.92E-04
COD	1.73E-01	2.57E-01
Cr	5.35E-04	7.96E-04
Cu	1.87E-06	2.78E-06
C_xH_y	4.51E-04	6.72E-04
C_xH_y chloro	3.81E-05	5.67E-05
Cyanide	9.59E-07	1.43E-06
Detergent/oil	4.49E-04	6.68E-04
Dissolved organics	4.07E-03	6.06E-03
Dissolved solids	1.18E+01	1.76E+01
Fe	2.84E-02	4.22E-02
Fluoride ions	9.59E-04	1.43E-03
H_2SO_4	5.06E-03	7.53E-03
Hg	3.76E-06	5.60E-06
K	4.28E-03	6.36E-03
Metallic ions	4.33E-03	6.44E-03
Mg	1.70E-04	2.52E-04
Mn	1.58E-02	2.35E-02
N-tot	7.34E-04	1.09E-03
Na	1.11E+00	1.65E+00
NH_3	5.69E-04	8.47E-04
NH_4+	2.37E-03	3.52E-03
Ni	8.85E-05	1.32E-04
Nitrate	1.87E-03	2.78E-03
Oil	2.09E-01	3.11E-01
Other organics	3.92E-02	5.84E-02
P_2O_5	1.09E-04	1.62E-04
Pb	1.44E-07	2.14E-07
Phenol	6.11E-05	9.10E-05

K	1.79E-01	2.67E-01
Kerosene	2.40E-04	3.58E-04
MDI (isocyanate)	1.32E-04	1.96E-04
Mercaptans	8.41E-07	1.25E-06
Metals	2.21E-04	3.29E-04
Methane	2.58E+00	3.84E+00
Methanol	4.65E-01	6.92E-01
Mn	2.12E-03	3.16E-03
N-nitrodimethylamine	7.74E-03	1.15E-02
N_2O	4.24E-03	6.31E-03
Na	4.13E-03	6.15E-03
Naphthalene	5.52E-04	8.21E-04
Ni	4.02E-04	5.98E-04
Non methane VOC	3.02E+00	4.49E+00
NO_x	5.97E+00	8.88E+00
Organic substances	4.60E-02	6.85E-02
Particulates	6.90E-01	1.03E+00
Particulates (PM10)	1.36E+00	2.02E+00
Particulates (unspecified)	5.14E-01	7.65E-01
Pb	3.08E-04	4.58E-04
Phenol	1.36E-01	2.03E-01
Sb	8.63E-06	1.28E-05
Se	5.77E-05	8.59E-05
SO_2	1.98E-01	2.95E-01
SO_x	1.10E+01	1.64E+01
Tetrachloroethene	7.00E-06	1.04E-05
Tetrachloromethane	1.98E-05	2.95E-05
Trichloroethene	6.81E-06	1.01E-05
Vinyl chloride	3.00E-10	4.47E-10
VOC	1.90E+00	2.82E+00
Water vapor	6.49E+02	9.66E+02
Zn	1.01E-03	1.50E-03

Phosphate	2.53E-03	3.76E-03
Sulphate	6.08E-01	9.05E-01
Sulphur/sulphide	8.04E-06	1.20E-05
Suspended solids	4.26E-01	6.34E-01
Vinyl chloride	2.51E-31	3.74E-31
Zn	7.82E-04	1.16E-03

Solid Waste Emission

Substance	**lb per MLF**	**kg per $10^3 m^3$**
Boiler ash	3.49E+00	5.19E+00
Chemical waste (inert)	3.29E-02	4.89E-02
Chemical waste (regulated)	5.40E-02	8.03E-02
Construction waste	9.07E-04	1.35E-03
Industrial waste	1.22E-01	1.81E-01
Metal scrap	1.71E-04	2.55E-04
Mineral waste	9.74E-01	1.45E+00
Paper/board packaging	5.63E-05	8.38E-05
Plastics packaging	1.88E-03	2.80E-03
Slags/ash	2.40E-01	3.57E-01
Solid waste	1.33E+02	1.98E+02
Special waste	4.46E-03	6.64E-03
Unspecified	1.38E-04	2.05E-04
Waste in incineration	1.92E-02	2.86E-02
Waste to recycling	4.25E-03	6.32E-03
Wood packaging	9.22E-05	1.37E-04
Wood waste	3.77E-01	5.61E-01

Nonmaterial Emission

Substance	**bq per MLF**	**bq per $10^3 m^3$**
Radioactive sub. to air	5.49E+06	8.16E+06

APPENDIX 3:   LVL AND I-JOIST MILL SURVEY

CORRIM SURVEY
The Consortium for Research on Renewable Industrial Materials (CORRIM II)

Laminated Veneer Lumber (LVL)/Composite I-Beam Plants
6-15-2001

This CORRIM survey is designed specifically for laminated veneer lumber and composite I-beam plants. There are two sections for this survey. Complete the section(s) that apply to your facilities. The white paper section relates to the production of LVL and the green paper section involves composite I-beam production. Questions will be concentrated on annual production, electricity production and usage, fuel use, material flows, and environmental emissions. We realize that you may not have all the information requested, especially when it comes to specific equipment/processing groups or what we call 'machine centers.' The data you are able to provide will be appreciated. Our intent is to maintain the confidentiality of the companies that supply the data for this survey.

The information from this survey will be used in a project by CORRIM II, a consortia comprised of universities, industry, and government groups. CORRIM is conducting a life-cycle assessment that will describe environmental influences of building materials and will focus our initial effort on structural building materials. CORRIM's objective is to acquire a database and produce life-cycle models of environmental performances for building materials. The database will be the basis for the scientific evaluation of feasible alternatives affecting the environmental releases and energy requirements of building materials through their life cycle. It is hoped that the output of the study will be used to competitively position wood in the marketplace over other types of building materials.

Company: ______________________________

Facility Site (city, state): ______________________________

Should we have a follow-up question about the data, please provide the name and the following information for the contact in your company.

Name: ____________________ Title: ____________________

Telephone: ____________________ E-mail: ____________________

If you have questions about the survey, contact:

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Graduate Research Assistant
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289 Richardson Hall
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eric.dancer@orst.edu

LVL Annual Production (Please provide units of measurement if different than stated)				
				TOTAL PRODUCTION
1.	Annual LVL production, 2000		ft^3	
2.	Veneer			
	a. Produced Veneer:			
	i. Used in Mill		MSF 3/8 in. basis	
	ii. Sold		MSF 3/8 in. basis	
	b. Purchased Veneer:			
	i. Dry		MSF 3/8 in. basis	
	ii. Green		MSF 3/8 in. basis	
	c. Sold Veneer			
	i. Dry		MSF 3/8 in. basis	
	ii. Green		MSF 3/8 in. basis	
	d. Transportation method(s) and average delivery distance for veneer			
	Truck (% of total)		Average delivery miles	
	Rail (% of total)		Average delivery miles	
	Other (% of total)		Average delivery miles	
	Total (%)	100		

3. Do you either peel/dry or dry veneer on site ____ Yes, ____ No?
   If yes, be sure to complete the relevant pages (page 9 through 11) of this survey.

Annual Energy Consumption (Please provide units of measurement if different)

If you have completed a 2000 Annual Fuel and Energy Survey for AF&PA, you may want to attach the survey and skip to the next section entitled "Other Annual Production." Please include all fuel use data relating to forklifts, loaders, and any other equipment used in your operations.

1.	Purchased electricity		KWH	________
2.	Purchased steam		lbs (at temperature °F?)	________
3.	Coal		Tons	________
4.	Hog Fuel	*Self-generated*	Tons	________
		Purchased	Tons	________
5.	Wood Waste		Tons	________
6.	Residual Fuel Oil		42 Gal. Bbls.	________
7.	Distillate Fuel Oil		42 Gal. Bbls.	________
8.	Liquid Propane Gas		Gallons	________
9.	Natural Gas		ft^3	________
10.	Gasoline and Kerosene		Gallons	________
11.	Diesel		Gallons	________
12.	Other (Specify)		________	________
13.	Less energy sold or transferred (if you generated any of these)			
	a. Electricity		KWH	________
	b. Steam		lbs (at temperature °F?)	________
	c. Hog fuel		Tons	________
	d. Wood waste		Tons	________

14. If you have a boiler, what is its heat source? Check appropriate box.
    - G Hogged fuel
    - G Oil
    - G Natural gas
    - G Other

15. If you have a boiler, how much electricity is used to operate it? KWH

Other Annual Production Data

1. Formulation and usage of resin, fillers, and other components

Component Type	Range % of Solid by Weight	Total annual use (lbs.)
Phenol formaldehyde		
Extender and filler		
Catalyst (NaOH)		
Water		
Other (please specify)		

Transportation method and distance for resin

Truck (% of total)	______	Average delivery miles	____________
Rail (% of total)	______	Average delivery miles	____________
Other (% of total)	______	Average delivery miles	____________
Total (%)	100		

2. Hot Pressing

Type and number of press(es) (i.e., RF, continuous, platen, etc.)	
Operating Temperature	EF
Pressure applied	psi
Press Time (check type)	min:sec

G Continuous press

G Single opening platen press

Source of Heat for Press

G Thermal Fluid (Hot Oil) heated by		
Natural Gas	ft^3	
Electricity	KWH	
G Steam	lbs	
G Radio Frequency	KWH	
G Microwave Frequency	KWH	
G Other		

Annual Material Flow

This is a general material flow survey for LVL mills. This survey is designed to trace all wood during production. Please check the box that pertains to your mill and answer related questions.

Veneer

1.	Veneer loss	Tons	____________

Lay-up

1.	Lay-up scrap	Tons	____________
2.	Resin loss	lbs.	____________

Sawing & Trimming

1.	Panel trim	Tons	____________
2.	Saw dust	Tons	____________

Rip Saw

1.	Saw dust	Tons	____________

Quality Control

1.	Tested LVL used	$ft.^3$	____________

Water use by source

1.	Municipal water source	Gallons	____________
2.	Well water source	Gallons	____________
3.	Recycled water source	Gallons	____________

Annual Emission Control Device and Environmental Emission

The following is a chart of emission control devices and a listing of chemical compounds that are observed and/or permitted. Please fill in all information related to the control devices. Then list all compounds that are collected and known for the mill for all control device sources. If you recently applied for an air permit, use those numbers. Fill in all that apply and for which you have data.

Annual Emission Control Device (ECD)- Electricity, Fuel Usage, and Emission Output					
	ECD 1	**ECD 2**	**ECD 3**	**ECD 4**	**ECD 5**
Equipment controlled (i.e., boiler, press, dryer, etc.)					
Model/ Type					
Year Installed					
Electricity used to operate ECD; either KWH or % of total plant use					
Natural Gas used to operate ECD; either $ft.^3$ or % of total plant use					

Annual Emission to Air (Please provide units of measurement if different)					
Organic Compound	**ECD 1**	**ECD 2**	**ECD 3**	**ECD 4**	**ECD 5**
Equipment controlled (i.e., boiler, press, etc.)					
Units	Tons/yr	Tons/yr	Tons/yr	Tons/yr	Tons/yr
CO_2					
CO					
NO_X					
SO_2					
VOC					
Acrolien*					
Methanol*					
Phenol*					
Acetaldehyde*					
Formaldehyde*					
Propionaldehyde*					
Water Vapor					
PM10					
Particulate					
*HAPS; you may want to provide total HAPS rather than specific chemicals					
Other (Please specify)					

Annual Emission to Land (please provide units of measurement)		
Emission	**Quantity (i.e. tons, lbs.)**	**Method of disposal or end use (i.e. land fill, landscaping)**
Bark/wood waste		
Boiler ash and fly ash		
Recovered particulates from pollution abatement equip.		
Water		
Other (Please specify)		

Machine Center Breakdown for Electricity and Fuel Use

Fill in all that apply and for which you have data. If you don't have a given machine center such as a co-generator, draw a line through that row and write none.

	Model/Type	**Annual electricity**	**Fuel Usage**
Machine Center	**Year Installed**	**Million KWH or % of the total use for mill**	**% of total use for mill**
Boiler(s)			
Co-generator			
Lay-up			
Press(es)			
Billet Cuts			
Rip Saw			

If you do not peel or dry veneer or produce I-beams, congratulations you have completed the survey! However, if you do, please complete the following pages.

Complete the following pages if you peel and dry or dry veneer in your LVL operation.

Please fill in all the information that pertains to your plant. Do not provide any additional information for operations not in your plant.

Machine Center Breakdown for Electricity and Fuel Usage

Fill in all that apply and for which you have data. If you do not have a given machine center, draw a line through that row and write None. Please provide units.

Machine Center	Model/Type	Annual Electricity Usage	Fuel Usage
	Year Installed	KWH of % of total electricity use for mill	% of total use for mill
Debarking			
Log Conditioning			
Peeling and Clipping			
Drying			

Annual Material Flow for Bucking, Peeling, and Drying

This is a general material flow survey for LVL mills. This survey is designed to trace all wood components generated during production. Please check the box that pertains to your mill and answer related questions.

G **Debarking and Bucking**		
1. Bark produced annually	Tons	
2. Wood chips produced	Tons	

G **Peeling and Chipping**		
1. Volume of peeler core	ft^3 or pieces (give lengths)	
2. Green clippings	Tons	
G **Veneer Dryer**		
1. Veneer downfall	Tons	

1. For dryer(s), check box type, heat source and give the annual fuel consumption if known:		
G Type of dryer G longitudinal G cross flow G jet		
G Steam	lbs	
G Natural gas direct-fired	ft^3	
G Hog fuel direct-fired (fuel cell)	tons	
G Other		

2. In regard to the dryer(s):			
Wood species dried and approximate percentage of total:			
Species		%	
Species		%	
Species		%	
Average moisture content into dryer		% ovendry basis	
Average moisture content out of dryer		% ovendry basis	
Redry rate		%	

3. Transportation method used to bring in your logs for veneer (check source):

G Truck (% of total) Average delivery miles ____________________

G Rail (% of total) Average delivery miles ____________________

G Other Average delivery miles ____________________

Complete the following pages if you produce composite I-beams in your plant.

Please fill in all information relevant to producing I-beams. Do not provide any information for operations not in your plant. Please provide the data on an annual basis for the year which the data is reported.

1. Annual I-Beam Production for 2000

Product (Series)	Amount (lin.ft.)	Beam Depth (in.)	Flange dim. (in. x in.)

2. I-Beam Construction-Web

	% of total	M 3/8's
a. OSB		
b. Plywood		
Total	100	

Transportation Method and Delivery Distance for OSB

Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100		

Transportation Method and Delivery Distance for Plywood

Truck (% of total)		Average delivery miles	
Rail (% of total)		Average delivery miles	
Other (% of total)		Average delivery miles	
Total (%)	100		

3. I-beam Construction - Flanges

	% of total used	(ft3 or MBF)
a. LVL	____________	____________
b. Finger-jointed lumber	____________	____________

Transportation Method and Delivery Distance for LVL

Truck (% of total)	____________	Average delivery miles	____________
Rail (% of total)	____________	Average delivery miles	____________
Other (% of total)	____________	Average delivery miles	____________
Total (%)	100		

Transportation Method and Delivery Distance for Finger-Jointed Lumber

Truck (% of total)	____________	Average delivery miles	____________
Rail (% of total)		Average delivery miles	
Other (% of total)	____________	Average delivery miles	____________
Total (%)	100		

4. Resin Use

a. Web Joint — Resin type ____________

Transportation Method and Delivery Distance for Web Joint Resin

Truck (% of total)	____________	Average delivery miles	____________
Rail (% of total)	____________	Average delivery miles	____________
Other (% of total)	____________	Average delivery miles	____________
Total (%)	____________	Average delivery miles	____________

Please include resin used in the Web joints of the I-beam in this section. Please state whether weight is given as wet or dry weight.

If you use the same resin for the web joint, finger-joint, and web to flange joint, complete the following table with total resin use and check this box ______G.

Otherwise, fill in resin use for web joint only.

Component Type	Range % of Solid by Weight	Total Annual Use (lbs.)
Resin		
Extender and filler		
Catalyst (NaOH)		
Water		
Other (please specify)		
Resin loss (lbs)		

b. Flange finger joint Resin type ____________

Transportation Method and Delivery Distance for Web Joint Resin

Truck (% of total) ____________ Average delivery miles ____________

Rail (% of total) ____________ Average delivery miles ____________

Other (% of total) ____________ Average delivery miles ____________

Total (%) ____________ Average delivery miles ____________

Please include resin used in the Web joints of the I-beam in this section. Please state whether weight is given as wet or dry weight.

Component Type	Range % of Solid by Weight	Total Annual Use (lbs.)
Resin-		
Extender and filler		
Catalyst (NaOH)		
Water		
Other (please specify)		
Resin loss (lbs)		

c. I-beam (web to flange) Resin type ____________

Transportation method and delivery distance for flange resin

Truck (% of total) ____________ Average delivery miles ____________

Rail (% of total) ____________ Average delivery miles ____________

Other (% of total) ____________ Average delivery miles

Total (%) 100

Please include resin used in the web to flange joints of the I-beam in this section. Please state whether weight is given as a wet or dry weight.		
Component Type	Range % of Solid by Weight	Total Annual Use (lbs.)
Resin		
Extender and filler		
Catalyst (NaOH)		
Water		
Other (please specify)		
Resin loss (lbs)		

Machine Center Breakdown for Electricity and Fuel Use

Fill in all that apply and for which you have data. If you don't have a given machine center that is listed here, draw a line through that row and write none.

Machine Center	Model/Type	Annual Electricity	Fuel Usage
	Year Installed	Million KWH or % of the Total Use for Mill	% of Total Use for Mill
OSB/Plywood saws			
LVL/FJ lumber saws			
Web joint shaper/router			
I-beam assembler			
I-beam saw			
Other (please specify)			
Curing Oven			
Steam			
Electricity			
Natural Gas			

Annual Emission Control Device and Environmental Emission

The following is a chart of emission control devices and a listing of chemical compounds that are observed and/or permitted. Please fill in all information related to the control devices. Then list all compounds that are collected and known for the mill for all control device sources. If you recently applied for air permit, use those numbers. Fill in all that apply and for which you have data.

Annual Emission Control Device (ECD)- Electricity, Fuel Usage, and Emission Output					
	ECD 1	ECD 2	ECD 3	ECD 4	ECD 5
Equipment controlled (i.e., boiler, press, dryer, etc.)					
Model/Type					
Year Installed					
Electricity used to operate ECD; either KWH or % of total plant use					
Natural gas used to operate ECD; either ft^3 or % of total plant use					
Annual Emission to Air (Please provide units of measurement if different)					
Organic Compound	ECD 1	ECD 2	ECD 3	ECD 4	ECD 5
Equipment controlled (i.e., boiler, press, etc.)					
Units	Tons/Yr	Tons/Yr	Tons/Yr	Tons/Yr	Tons/Yr
CO_2					
CO					
NO_X					
SO_2					
VOC					
Acrolien*					
Methanol*					
Phenol*					
Acetaldehyde*					
Formaldehyde*					
Propionaldehyde*					
Water Vapor					
PM 10					
Particulate					
*HAPS; you may want to provide total HAPS rather than specific chemicals					
Other (Please specify)					

Annual Emission to Land (Please provide units of measurement)		
Emission	Quantity (i.e., tons, lbs.)	Method of disposal or end use (i.e., land fill, landscaping)
Bark/wood waste		
Boiler ash and fly ash		
Recovered particulates from pollution abatement equipment		
Water		
Other (Please specify)		