Conclusions and Summary Report Environmental Life Cycle Assessment of Railroad Ties

ISO 14044 Compliant

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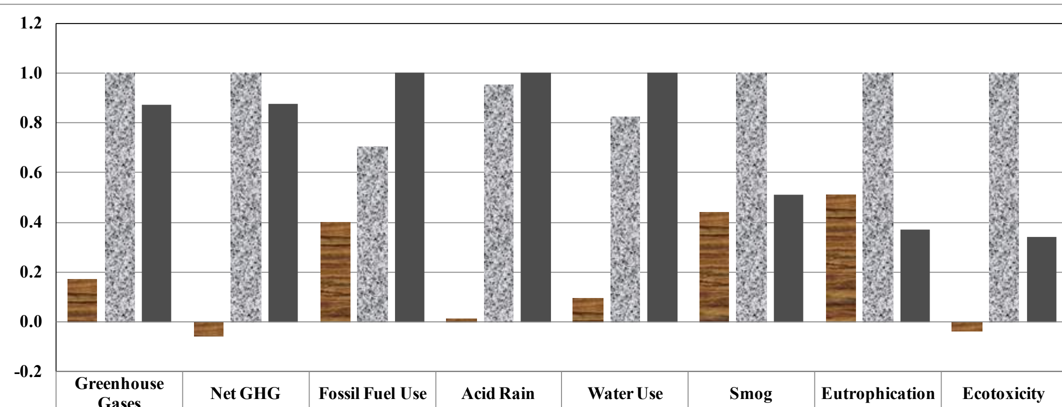
Conclusions and Summary Report

1. Conclusions & Executive Summary

The Treated Wood Council has completed a quantitative evaluation of the environmental impacts associated with the national production, use, and disposition of treated wood, concrete, and plastic/composite railroad ties, using life cycle assessment (LCA) methodologies and following ISO 14044 standards. The results for treated wood railroad ties are significant.

- **<u>Less Energy & Resource Use</u>:** Treated wood railroad ties require less total energy and less fossil fuel than concrete and plastic/composite railroad ties.
- **<u>Lower Environmental Impacts</u>:** Treated wood railroad ties have lower environmental impacts than concrete ties for all six impact indicator categories assessed: anthropogenic greenhouse gas, total greenhouse gas, acid rain, smog, eutrophication, and ecotoxicity-causing emissions. Creosote-treated wood railroad ties have lower environmental impacts than plastic/composite ties in five of six impact indicator categories assessed: anthropogenic greenhouse gas, total greenhouse gas, acid rain, smog, and ecotoxicity-causing emissions.
- **<u>Decreases Greenhouse Gas Levels</u>:** Use of treated wood railroad ties lowers greenhouse gas levels in the atmosphere whereas concrete and plastic/composite railroad ties increase greenhouse gas levels in the atmosphere.
- **<u>Offsets Fossil Fuel Use</u>:** Increasing reuse of treated wood railroad ties for energy recovery will further reduce greenhouse gas levels in the atmosphere, while offsetting the use of fossil fuel energy.

Figure 1 Normalized impact indicator comparison (maximum impact = 1.0)



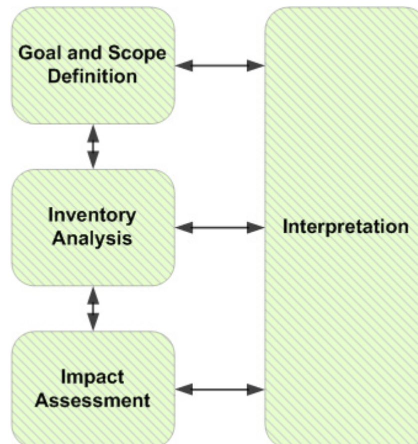
	Greenhouse Gases	Net GHG	Fossil Fuel Use	Acid Rain	Water Use	Smog	Eutrophication	Ecotoxicity
Creosote-treated tie	0.17	-0.057	0.40	0.014	0.10	0.44	0.51	-0.037
Concrete tie	1.0	1.0	0.70	1.0	0.82	1.0	1.0	1.0
Plastic/composite tie	0.87	0.87	1.0	1.0	1.0	0.51	0.37	0.34

Impact indicator values were normalized to better support comparisons between products and to understand the quantitative significance of indicators. Product normalization sets the cradle-to-grave life cycle value of maximum impact to 1.0, and all other values are a fraction of 1.0. The normalized results are provided in Figure 1.

2. Goal and Scope

The goal of this study is to provide a comprehensive, scientifically-based, fair, and accurate understanding of environmental burdens associated with the manufacture, use, and disposition of railroad ties using LCA methodologies. The scope of this study includes:

- A life cycle inventory of three railroad tie types: preservative-treated wood, concrete, and plastic/composite. Creosote was chosen as a representative preservative for assessment of treated wood railroad ties.
- Calculation and comparison of life cycle impact assessment indicators: anthropogenic greenhouse gas, total greenhouse gas, acid rain, smog, ecotoxicity, and eutrophication of water-bodies potentially resulting from life cycle air emissions.
- Calculation of energy, fossil fuel, and water use.



3. Quality Criteria

This LCA study was done in accordance with the principles and guidance provided by the International Organization for Standardization (ISO) in standards ISO/DIS 14040 and ISO/DIS 14044. The LCA procedures and findings were evaluated by a panel of external reviewers in accordance with Section 6 of ISO 14044. The external reviewers confirmed that the LCA followed the ISO standards and that the comparative assertions were done using equivalent functional units and equivalent methodological considerations.

4. Manufacturer Information

This LCA addresses three railroad tie products.

- The LCA for <u>treated wood</u> railroad ties includes weighted averages of primary data (i.e., survey responses from U.S. treaters of wood railroad ties).

- The LCAs for concrete and plastic/composite railroad ties represent general product categories, manufactured with different designs and material contents. These LCAs were prepared using secondary data sources and provide a basis for general comparison of products.

5. Product Description and Functional Unit

Railroads are a critical transportation element of the U.S. economy, distributing large quantities of material goods and oftentimes in a more efficient manner than road-based transportation. Railroad crossties are the base members, to which steel rails are attached to transfer load from the rails to the underlying ballast. The ties also provide the critical function of keeping the rails at the correct gauge and alignment. The railroad tie can be made of either wood, concrete, or plastic/composite materials.

Scope: Cradle-to-grave

Functional unit: one mile of Class 1 railroad per year of use. Tie size is 7 inch by 9 inch by 86 inch (or equivalent for non-wood product). Wood product treated with creosote preservative.

Service life assumed for this LCA:

- sawn wood product - 35 years
- concrete product - 40 years
- plastic/composite product - 40 years

Tie spacing in Class 1 mainline railroads:

- sawn wood product - 19.5 inches
- concrete product - 24 inches
- plastic/composite product - 19.5 inches

System boundary: from the extraction of the raw materials through processing, transport, primary service life, reuse, and disposal of the product.

Geographic boundary: U.S.

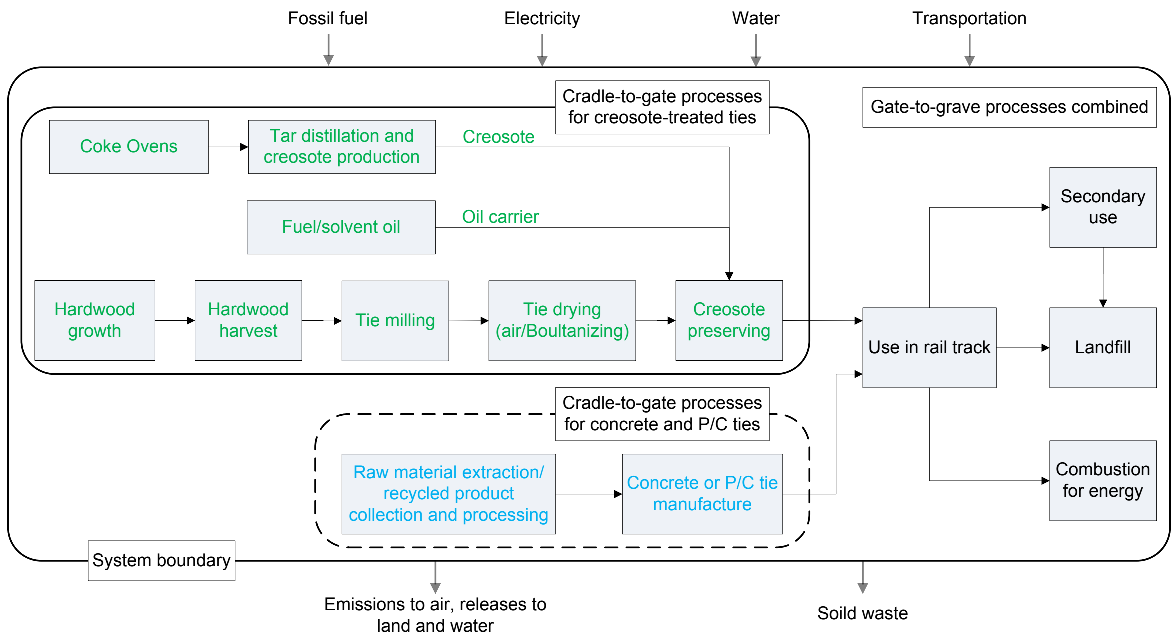
6. Life Cycle Inventory

The inventory analysis phase of the LCA involves the collection and analysis of data for the cradle-to-grave life cycle of the railroad ties. For each stage of the product life cycle, inputs of energy and raw materials, outputs of products, co-products and waste, and environmental releases to air, water, and soil are determined.

The system boundaries include all the production steps from extraction of raw materials from the earth (cradle) through to final disposition after service life (grave). Figure 2 illustrates the system boundaries and process flows for both wood and non-wood railroad ties assessed in this study.

The length of time a railroad tie remains in service varies widely, depending on a number of factors. For this assessment creosote-treated railroad ties were assumed to remain in service for 35 years. Concrete ties and plastic/composite ties are assumed to provide 40 years of service.

Figure 2 System boundary and process flows for railroad ties. Cradle-to-gate processes for treated wood are shown in green and concrete and plastic/composites are shown in blue. Gate-to-grave processes are shown in black as combined.



Unlike creosote-treated and plastic/composite ties installed with 19.5 inch spacing, concrete ties are installed at 24-inch spacing (2,640 ties per mile) and assumed to require nine-inches of additional rock ballast. Assumptions used in this LCA for disposition of railroad ties after service life include:

- Treated wood ties are recycled for secondary use, used for energy recovery, or disposed in a solid waste landfill;
- Concrete ties are assumed either to be recycled or landfilled; and
- Plastic/composite ties are assumed either to be recycled or landfilled.

7. Environmental Performance

The assessment phase of the LCA uses the inventory results to calculate total energy use, impact indicators of interest, and resource use. For environmental indicators, USEPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) is used to assess anthropogenic and total greenhouse gas, acid rain, smog potential, ecotoxicity, and eutrophication impacts potentially resulting from air emissions. The categories, energy use, resource use, and impact indicators, provide general, but quantifiable, indications of environmental performance. The results of this impact assessment are used for comparison of railroad tie products as shown in Table 1.

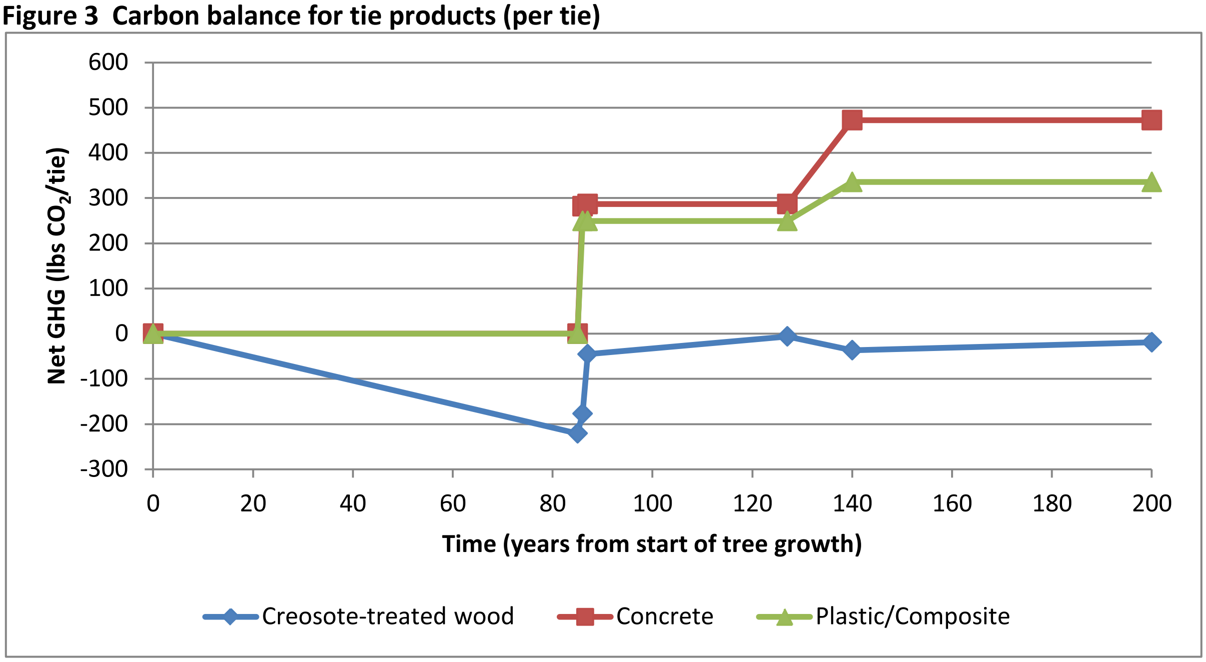
Table 1 Environmental performance of railroad ties (per mile of track/year of railroad service)

Impact category	Units	Treated wood tie	Concrete tie	Plastic/composite tie
Energy use				
Energy input (technosphere)	MMBTU	47	53	90
Energy input (nature)	MMBTU	39	112	143
Biomass energy	MMBTU	2.9	1.0	1.2
Environmental indicators				
Anthropogenic greenhouse gas	lb-CO_2-eq	5,355	30,928	26,978
Total greenhouse gas	lb-CO_2-eq	-1769	31,175	27,268
Acid rain air emissions	lb-H+ mole-eq	143	9,783	10,277
Smog potential	g NOx / m	25	58	29
Ecotoxicity air emissions	lb-2,4-D-eq	-6.9	188	4.2
Eutrophication air emissions	lb-N-eq	1.9	3.7	1.4
Resource use				
Fossil fuel use	MMBTU	88	154	220
Water use	gal	644	5,571	6,771

Wood products begin their life cycles removing carbon from the atmosphere (as carbon dioxide) and atmospheric carbon removal continues as trees grow during their approximate 80-year growth cycle, providing an initial life cycle carbon credit. Approximately half the mass of dry wood fiber is carbon. Transportation and treating operations are the primary sources of carbon emissions in the manufacture of treated wood products.

The concrete and plastic/composite ties begin their life cycles either as raw materials or with the recycling of products. Both processes result in carbon emissions. Burdens associated with recycling, including transportation, sorting, cleaning, and melting, must be included in the manufacturing stage.

Figure 3 Carbon balance for tie products (per tie)



Minimal impacts are required for both treated wood, concrete, and plastic/composite ties in the service life stage. Following the service life stage, ties are reused or disposed. For creosote-treated ties, energy is commonly recovered by combusting the wood and fossil-based carbon constituents of creosote. The combusted products generate heat or make electricity. The ability to recovery energy from used creosote-treated railroad ties, after their rail service life, adds to the net GHG credit of the product. The carbon balance of railroad ties, through the life cycle stages, is shown in Figure 3.

8. Additional Information

This study is further detailed in a Procedures and Findings Report completed April 3, 2013 and is available upon request from the Treated Wood Council at www.treated-wood.org/contactus.html.

This study has been published in the peer-reviewed *Journal of Transportation Technologies* (Vol. 3, April 2013, pp 149-161) and is available at http://www.scirp.org/journal/jtts.