Conclusions and Summary Report:

Environmental Life Cycle Assessment of Chromated Copper Arsenate-Treated Utility Poles with Comparisons to Concrete, Galvanized Steel, and Fiber-Reinforced Composite Utility Poles

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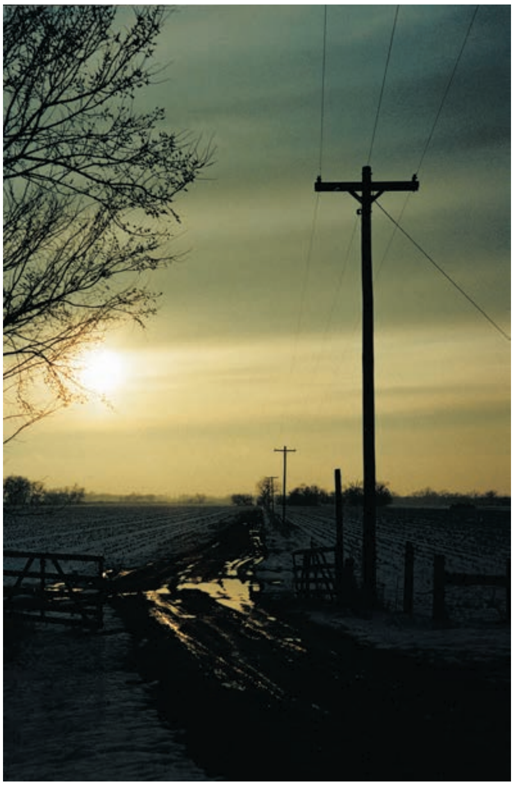
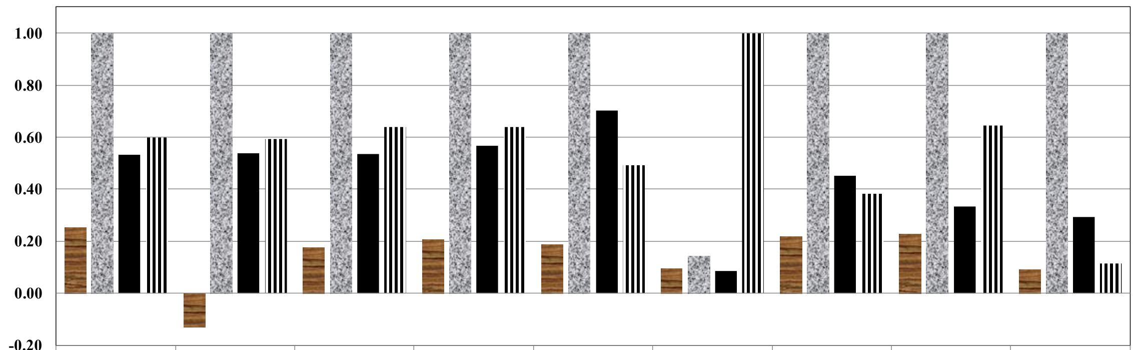
Conclusions and Summary Report

Arch Wood Protection commissioned AquAeTer, Inc., an independent consulting firm, to prepare a quantitative evaluation of the environmental impacts associated with the national production, use, and disposition of chromated copper arsenate (CCA)-treated, concrete, galvanized steel, and fiber-reinforced composite utility poles using life cycle assessment (LCA) methodologies and following ISO 14044 standards. The comparative results confirm:



- **<u>Less Energy & Resource Use</u>:** CCA-treated utility poles require less total energy and less fossil fuel than concrete, galvanized steel, and fiber-reinforced composite utility poles. CCA-treated utility poles require less water than concrete and fiber-reinforced composite utility poles.
- **<u>Lower Environmental Impacts</u>:** CCA-treated utility poles have lower environmental impacts in comparison to concrete, steel, and fiber-reinforced composite utility poles for all six impact indicator categories assessed: anthropogenic greenhouse gas, net greenhouse gas, acid rain, smog, ecotoxicity, and eutrophication-causing emissions.
- **<u>Decreases Greenhouse Gas Levels</u>:** Use of CCA-treated utility poles lowers greenhouse gas levels in the atmosphere whereas concrete, galvanized steel, and fiber-reinforced composite utility poles increase greenhouse gas levels in the atmosphere.
- **<u>Offsets Fossil Fuel Use</u>:** Reuse of CCA-treated utility poles for energy recovery in permitted facilities with appropriate emission controls will further reduce greenhouse gas levels in the atmosphere, while offsetting the use of fossil fuel energy.

Figure 1 Impact indicator comparison (normalized to maximum = 1.0)



	Anthropogenic GHG	Net GHG	Fossil Fuel Use	Total Energy Input	Acid Rain	Water Use	Smog	Eutrophication	Ecotoxicity
CCA pole	0.25	-0.13	0.17	0.21	0.19	0.095	0.22	0.23	0.092
Concrete pole	1.0	1.0	1.0	1.0	1.0	0.14	1.0	1.0	1.0
Steel pole	0.53	0.54	0.53	0.57	0.70	0.085	0.45	0.33	0.29
FRC pole	0.60	0.59	0.64	0.64	0.49	1.0	0.38	0.64	0.11

Impact indicator values for the cradle-to-grave life cycle of CCA-treated utility poles were normalized. The cradle-to-grave pole product with the highest impact value receives a value of one and the other pole product impacts are then a fraction of one. The normalized results are provided in Figure 1.

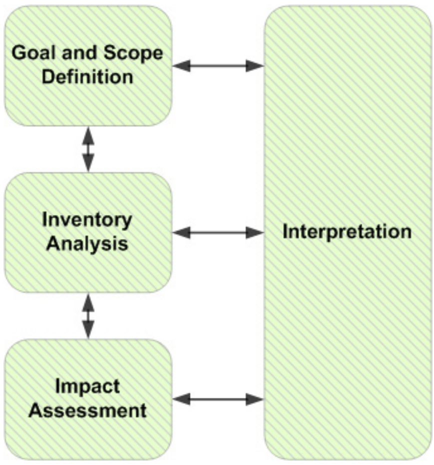
Goal and Scope

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 utility poles using LCA methodologies. The scope of this study includes:

- A life cycle inventory of CCA-treated, concrete, galvanized steel, and fiber-reinforced composite utility poles, modified from a life cycle inventory of pentachlorophenol-treated utility poles done for the Treated Wood Council.
- Calculation and comparison of life cycle impact assessment indicators: anthropogenic greenhouse gas, net greenhouse gas, acid rain, smog, ecotoxicity, and waterborne eutrophication impacts potentially resulting from life cycle air emissions.
- Calculation of energy, fossil fuel, and water use.

Quality criteria

This study was done as an extension of work performed by the Treated Wood Council and is not intended as a stand-alone LCA. The study includes most elements required for an LCA meeting the International Organization for Standardization (ISO) guidelines as defined in standards ISO/DIS 14040 "Environmental Management – Life Cycle Assessment – Principles and Framework" and ISO/DIS 14044 "Environmental Management – Life Cycle Assessment – Requirements and Guidelines". However, there was no external peer review of the CCA components of this LCA.



Manufacturer Information

CCA is listed in the American Wood Protection Association (AWPA) Standard P5 for Waterborne Preservatives. CCA preservative use in utility poles is almost exclusively for treatment of Southern pine.

The LCA for <u>CCA-treated utility poles</u> is based on Arch Wood Protection-provided inventory data. Arch Wood Protection supplies the CCA preservative to wood treating companies treating poles in accordance with appropriate AWPA standards.

The LCAs for concrete, galvanized steel, and fiber-reinforced composite utility poles represent general product categories, manufactured with different designs and material contents. These LCAs provides a basis for general comparison of products.

Life Cycle Inventory

For comparative purposes this LCA evaluates utility poles that commonly are used interchangeably. The products, CCA-treated Southern pine, treated in accordance with AWPA standards, concrete, galvanized steel, and fiber-reinforced composite utility poles are compared at a functional unit of one 45-foot pole meeting National Electrical Safety Code Grade C design standards.

The inventory analysis phase of the LCA involves the collection and analysis of data for the cradle-to-grave life cycle of the utility pole. 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.

Scope: cradle-to-grave

Functional unit: one 45-foot utility pole capable of 2,400 pounds of horizontal load applied two feet from the pole's tip.

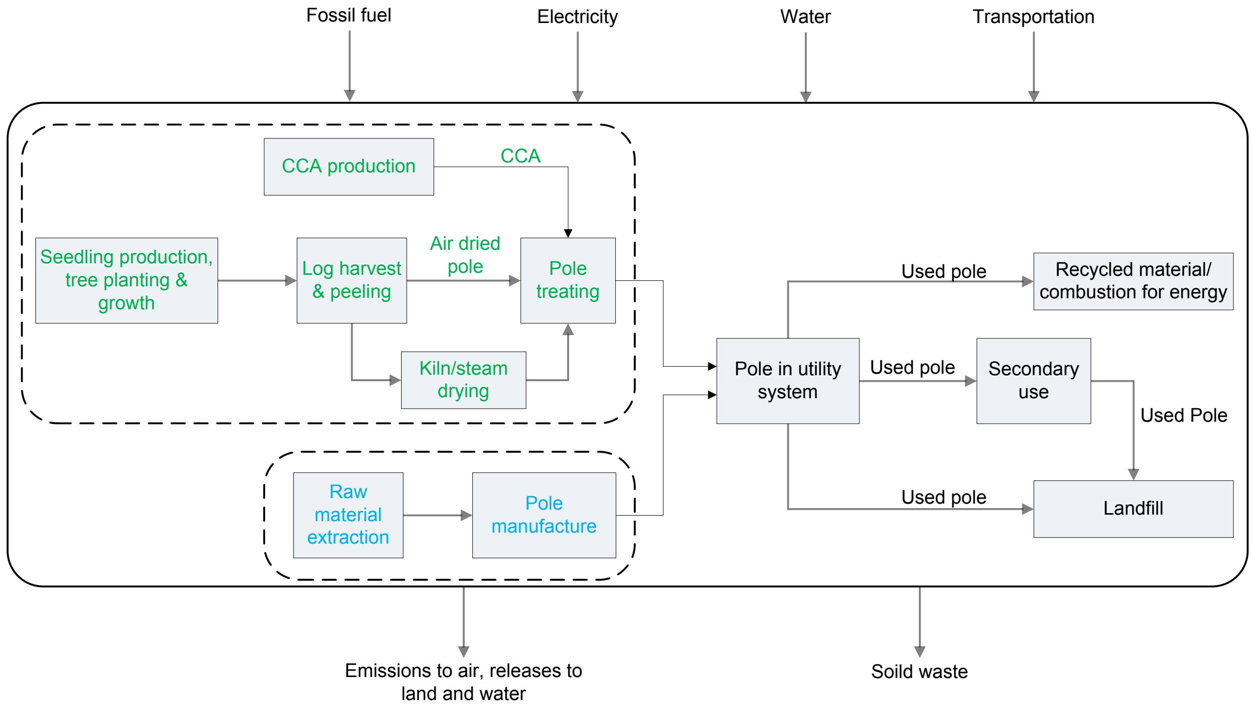
Service life: 60 years

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

Geographic boundary: U.S.

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

Figure 2 System boundary and process flows for utility poles (cradle-to-gate processes for CCA-treated are shown in green and non-wood products are shown in blue)



The length of time a utility pole remains in a utility line is dependent upon a number of factors. Often, poles are removed from service before the end of their useful service life, such as for road widening. Assumptions used in this LCA for disposition of utility poles after service life include:

- CCA-treated poles are recycled for secondary use or disposed in a solid waste landfill
- Concrete poles are disposed in a solid waste landfill
- Steel poles are recycled
- Fiber-reinforced composite poles are burned for energy recovery or disposed in solid waste landfills

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 net greenhouse gas, acid rain, smog potential, ecotoxicity, and eutrophication impacts potentially resulting from air emissions. The categorized 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 all utility pole products as shown in Table 1

Table 1 Environmental performance (per pole)

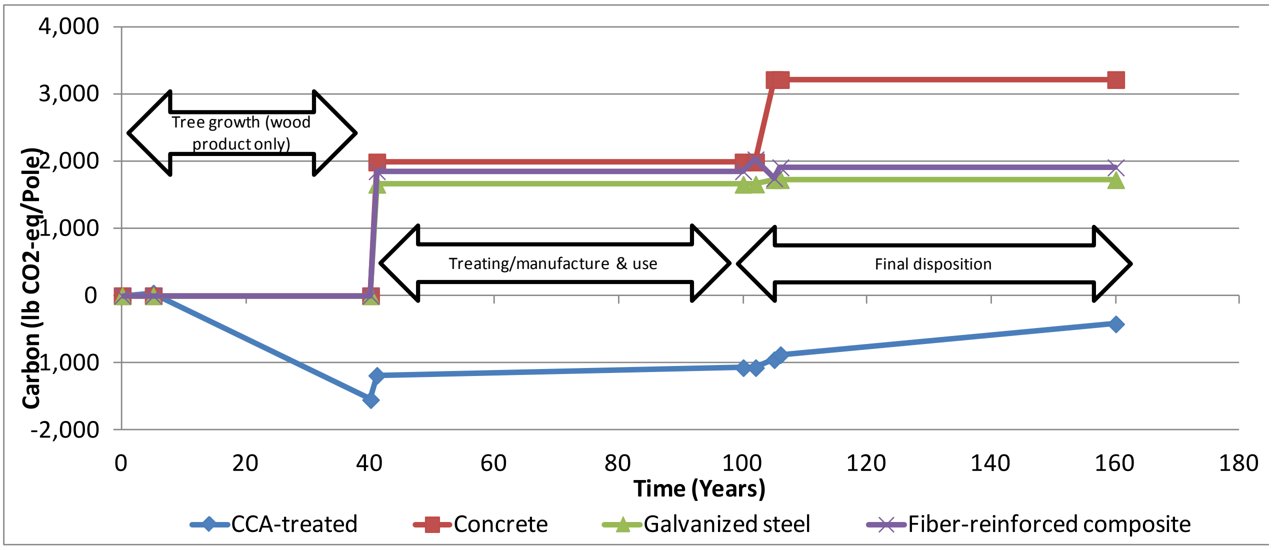
Impact category	Units	CCA-treated pole	Concrete pole	Galvanized steel pole	FRC pole
Energy use					
Energy input from technosphere	MMBTU	2.0	6.5	2.9	0.19
Energy input from nature	MMBTU	1.5	10	6.5	11
Biomass energy	MMBTU	0.56	0.094	0.11	-0.012
Impact indicators					
Anthropogenic GHG emissions	lb-CO2-eq	803	3,190	1,699	1,911
Net GHG emissions	lb-CO2-eq	-419	3,213	1,725	1,908
Acid rain air emissions	lb-H+ mole-eq	166	886	622	436
Smog potential	g NOx / m	1.1	5.0	2.3	1.9
Ecotoxicity air emissions	lb-2,4-D-eq	1.7	19	5.5	2.1
Eutrophication air emissions	lb-N-eq	0.072	0.32	0.10	0.20
Resource use					
Fossil fuel use	MMBTU	2.7	16	8.4	10
Water use	gal	119	180	106	1,248

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 40-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.

Non-wood utility pole products begin their life cycle with the extraction of resources, such as limestone or silica sand or carbon-sequestered resources such as oil and coal, and require energy to convert resources into manufactured products.

Minimal impacts are required for both wood and non-wood products in the service life stage. Following the service life stage, CCA-treated wood poles are recycled for secondary uses or disposed in landfills. Non-wood material poles are recycled, disposed in landfills, or recycled for energy. The carbon balance of each utility pole product, through the life cycle stages, is shown in Figure 3.

Figure 3 Carbon balance for utility pole products (per pole)



Note: Net carbon less than zero is a reduction of greenhouse gas levels in the atmosphere because of the product's manufacture, use and disposal. Net carbon greater than zero is an increase of greenhouse gas levels in the atmosphere.

Additional Information

This study is further detailed in a Life Cycle Assessment Report completed in March 2013 and is available upon request from Arch Wood Protection at 360 Interstate North Parkway, Suite 450, Atlanta, GA 30339.

This study is based on data collection and analysis done as part of an LCA on pentachlorophenol-treated utility poles. A manuscript of the pentachlorophenol-treated utility poles findings was published in the peer-reviewed Renewable and Sustainable Energy Review and is available at http://dx.doi.org/10.1016/j.rser.2011.01.019.