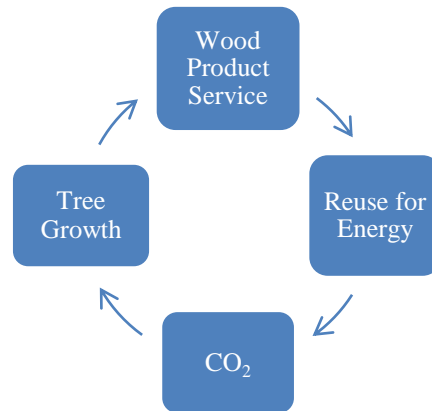


END-OF-LIFE MANAGEMENT OF PRESERVED WOOD THE CASE FOR REUSE FOR ENERGY



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EXECUTIVE SUMMARY

This paper summarizes the energy and greenhouse gas (GHG) ramifications of end-of-life management options for preserved wood products.

GHG emissions represent a negative 70,000 pounds of carbon dioxide equivalents (CO₂-eq.) per Mcf of preserved wood when end-of-service-life preserved wood is used for the generation of energy (in comparison to a reduction of approximately 10,000 pounds if preserved wood was placed in a landfill). This offset annually would be equal to the GHG emissions of approximately 870,000 U.S. citizens or about 0.29 percent of the U.S. total GHG output.

The energy savings of using end-of-service-life preserved wood for the generation of energy is equivalent to approximately 32 million barrels of oil annually, or the fossil fuel use of approximately 646,000 U.S. citizens (about 0.21 percent of total U.S. fossil fuel use).

The impact on U.S. landfill capacity is large. Disposal in landfills equates to approximately 9 percent of annual U.S. landfill air space or the equivalent disposal of approximately 28 million U.S. citizens.

Federal, State, and regional governments and agencies should encourage and reward beneficial reuse of preserved wood following its removal from service. Recommended actions toward this end include:

- Include preserved wood that has been removed from service within the definition of “renewable energy biomass” in any laws or regulations. Any incentives used to encourage the use of renewable biomass should apply equally to preserved wood biomass.
- Repeal laws that prevent or ban the use of preserved wood for energy.
- Do not pass laws that would regulate preserved wood removed from service.

1. INTRODUCTION

Wood products are treated with wood preservatives to extend their service lives in weather exposed or wet environments, or in environments subject to microbial and insect attack. Preservatives allow products that would otherwise fail within months or years to last from decades to nearly a century. Often, preserved wood products can be reused in less demanding applications, such as poles being used for fencing, thereby further extending their service lives. Eventually these products degrade due to use, weathering, and decay to the point that they must be removed from their primary service application and replacement products installed. End-of-life management options for those removed preserved wood products generally include reuse in secondary service, abandonment at use site, disposal in non-hazardous waste landfills, or reuse as an energy source.

Wood preservatives are approved for use by the United States Environmental Protection Agency (EPA). The EPA has allowed end users of such products to dispose of preserved wood products without hazardous waste restrictions.

Environmental improvement opportunities are available through the beneficial reuse of preserved wood at the end of life. Such technologies currently exist, but are underutilized. This paper examines the energy and greenhouse gas (GHG) ramifications of end-of-life management options.

2. PROPERTIES OF PRESERVED WOOD

The properties of preserved wood relevant to end-of-life management choices vary related to wood species, the formulations of wood preservatives, and the condition of the products when removed from service.

2.1. Properties of Wood

Specific gravities and dry densities of representative wood species used for preserved wood products are listed in Table 1. Southern pine is not a species in itself, but a grouping of similar species as listed on the table. Similarly, oak (used for crossties) is typically a mixture of specific oaks and other hardwoods. Dry densities of wood species vary from 19 to 37 pounds per cubic foot (pcf).

Table 1 - Specific Gravity and Density of Wood Species

Wood Species	Specific Gravity	Bone Dry Density (pcf)	Species Fraction
Density based on volume at MC:	Green		
Southern Pine, average	0.51	31.7	70%
Loblolly	0.47	29.3	
Longleaf	0.55	34.6	
Shortleaf	0.47	29.3	
Slash	0.54	33.7	
Douglas fir, Coast	0.45	28.1	20%
Cedar, Western red	0.31	19.3	
Oak, average	0.56	35.2	10%
Oak, red, black	0.56	34.9	
Oak, red, Northern red	0.56	34.9	
Oak, red, Southern red	0.52	32.4	
Oak, white, Burr	0.58	36.2	
Oak, white, White	0.60	37.4	
Weighted Average Wood		31.34	

Notes:

Specific Gravity from USDA-FPL Wood Handbook Table 4-3b

Moisture Content from USDA-FPL Wood Handbook Table 3-3

All wood density calculations are based on the specific gravity of wood in the green condition because product dimensions are determined at that time and assumed to be constant through life.

Wood density = specific gravity x water density

The fuel or heat value of wood is an important property when use for energy is being considered. The heat value of untreated wood is generally constant at approximately 9,000 BTU per pound (EPA 1995), but varies on a volume basis due to different densities of species. Heat value varies

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greatly with moisture content. The effective heat value is reduced by the amount of water in the wood since water must be evaporated and heated to exhaust gas temperature in a combustion process. Moisture content for wood is traditionally stated on a dry-wood basis, which is equal to the weight of water divided by the dry weight of wood. Green sapwood biomass typically contains approximately 100 percent moisture or more. At 100 percent (meaning one part water for each part dry wood mass), the contained heat is approximately 4,500 BTU per pound and the effective heat content (after heating and evaporating the water) of wood fuel is approximately 3,200 BTU per pound. Table 2 includes the effective theoretical efficiency of wood fuel at various moisture contents (both dry and wet basis). As wood moisture increases, more carbon dioxide (CO₂) is released to the atmosphere per unit of useful heat production, as shown by the Effective CO₂ Intensity columns.

Table 2 - Effective Theoretical Efficiency of Wood Fuel

Wood Fuel Moisture vs Net Efficiency						Effective CO ₂	
Moisture (dry basis)	Moisture (wet basis)	Total Heat wood only (BTU/lb)	Effective Heat less vapor (BTU/lb)	Efficiency In/effect	Net Efficiency	Intensity	
						CO ₂ lb/MMBTU	Carbon kg C/MMBTU
0%	0%	9,000	9,000	100%	70.0%	195	24.2
10%	9%	8,182	8,054	98%	68.9%	198	24.6
20%	17%	7,500	7,244	97%	67.6%	202	25.0
30%	23%	6,923	6,539	94%	66.1%	206	25.6
40%	29%	6,429	5,917	92%	64.4%	212	26.3
50%	33%	6,000	5,360	89%	62.5%	218	27.1
70%	41%	5,294	4,398	83%	58.2%	235	29.1
100%	50%	4,500	3,220	72%	50.1%	273	33.8
150%	60%	3,600	1,680	47%	32.7%	418	51.8
200%	67%	3,000	440	15%	10.3%	1,330	164.8

Note:

Net efficiency assumes a boiler efficiency of 70 percent (efficiency*70%=net efficiency)

Preserved wood at the end of its service life is typically drier than “green¹” wood. While it can vary greatly depending on its previous use and storage conditions, the moisture content is typically about 20 percent. Wood fuel at this moisture content has effective heat value of approximately 7,200 BTU per pound.

¹ In this paper “green” refers to recently cut wood that has not been dried or preserved.

2.2. Properties Affected by Wood Preservation

The chemical constituents present in preserved wood need to be considered so that appropriate end-of-life management choices may be made. The amount of preservative in wood varies according to the intended use of the product. The specified retention for products is the total weight of active ingredients per cubic foot of wood within the outer zone of the wood. Interior zones of a preserved wood product, particularly in large cross-section pieces, such as poles, may contain little to no preservative. A brief overview of the primary wood preservative systems is included in Appendix 1.

Preserved wood products that are removed from primary service and put into a secondary service use are not disposed and, therefore, not waste. If disposed, used preserved wood is not hazardous waste by Federal regulations and even in states in which it may meet hazardous waste definitions, such as California, or require “special” handling, such as Oregon and Washington, it may be disposed in appropriate solid waste (non-hazardous) landfills. A detailed discussion of disposal regulatory requirements is available on the Western Wood Preservers Institute website at <http://www.wwpinstitute.org>.

2.3. Volume of Preserved Wood Products

Estimates of national treated wood removal volume could not be determined. Estimated annual preserved wood production in the U.S. (Smith, 2009) is approximately 640,000 Mcf (1Mcf = 1,000 cubic feet). Annual production volumes by preservative type are estimated to be 87,000 Mcf for creosote, 32,000 Mcf for oil-borne treatment, and 520,000 Mcf for water-borne preserved wood products. In addition, approximately 2,400 Mcf of lumber and plywood is protected with fire retardant (Vlosky, 2009). Estimated annual production of preserved wood by product type and by U.S. region are shown in Appendix 2.

3. CARBON CYCLE OF PRESERVED WOOD PRODUCTS

3.1. Cycle Overview

The cradle-to-grave life cycle of preserved wood products is similar to other wood products and agricultural products. Seeds sprout and grow using photosynthesis to extract CO₂ from the atmosphere to create hydrocarbon mass; the mature tree is harvested and converted through manufacturing processes into useful products, which serve their desired function; and then end-of-life disposition options result in some of the embodied carbon being returned to the atmosphere and some being sequestered in long-term (hundreds of years) storage. Instead of “ashes to ashes,” the cycle is CO₂ to CO₂.

3.2. Growth

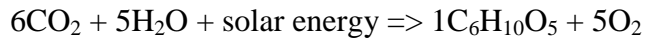
The life cycle for most commercially grown trees begins in nurseries where seeds are germinated and seedling trees are grown. Seedlings are planted in forest land or plantations that have been prepared for planting. Seedlings may also be planted in forests following fires. The area to be planted may have previously had mature trees harvested. Preparation may include cutting down undesired trees or shrubs, burning slash, herbicide application to kill or prevent weeds, and application of fertilizer. Seedlings may be planted by machine or by hand. Generally, there is a net release of carbon dioxide in this pre-planting phase of growth. This stage description does not apply to hardwoods, which mostly are naturally propagated from seeds.

Seedlings grow into mature trees over several decades. The total time to harvest varies by species, climate, and other site factors. Time to maturity² ranges from approximately 20 years to 100 years. Trees used in the pulp and paper industry may be smaller and younger than trees used for lumber or poles. Fertilizer may be added during the growth phase. Commercially managed forests are typically thinned two or three times during the growth cycle to prevent overcrowding and to enhance growth rates. Biomass removed during thinning may be utilized for energy production or as pulpwood.

² “Maturity” is the point when the tree is big enough to harvest for an intended purpose.

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Trees grow through the process of photosynthesis, in which carbon dioxide removed from the atmosphere and water from the ground react using collected energy from the sun to produce wood mass and release excess oxygen to the atmosphere. A simplified chemical reaction for the production of cellulose, the most common component of wood, is as follows:



According to the Forest Products Laboratory (2010), wood is approximately 50% cellulose ($\text{C}_6\text{H}_{10}\text{O}_5$), which is 44 percent carbon by mass. Lignin ($\text{C}_{10}\text{H}_{12}\text{O}_3$), comprising approximately 23 percent to 33 percent of wood, is 67 percent carbon by mass. Dry wood mass is, on average, approximately 48% carbon. Each cubic foot of wood contains approximately 15 pounds of carbon representing 55 pounds of carbon dioxide removed from the atmosphere.

3.3. Manufacture

Harvested logs are transformed into products and by-products through a series of manufacturing processes that vary, depending on the desired end products. Typical processes related to preserved wood products are discussed in the section below. Table 3 presents the representative products, wood and preservatives used, and service conditions.

Table 3 - Representative Preserved Wood Products

Product	Wood	Preservative	Service
Decking	Sawn softwood lumber	Copper based including ACQ and CA	Exterior above ground exposed to weather
Sill plates and framing	Sawn softwood lumber	Borate or copper-based.	Interior but potentially damp with insect damage or decay hazard
Fire retardant wood	Sawn softwood lumber and timber	Borate	Protected above ground locations where protection from fire required
Utility poles	Round, peeled, softwood	CCA, pentachlorophenol, copper naphthenate, or creosote	Exterior exposed to weather and in ground contact
Railroad ties	Sawn hardwood timber	Creosote or copper naphthenate, possibly with borate	Exterior exposed to weather and in ground contact

Notes: ACQ = alkaline copper quaternary, CA = copper azole, CCA = chromated copper arsenate.

A complete listing of preserved products, wood types, and services is detailed in American Wood Protection Association (AWPA) 2010.

Nearly all wood products first require removal of bark from logs. Debarking results in bark biomass that is a by-product used for mulch (decorative or as soil amendment) or fuel. Mulch

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decays aerobically over time, releasing most or all of its carbon to the atmosphere as CO₂. Use of bark as fuel biomass releases all the carbon as CO₂.

By volume, most logs are used to manufacture lumber. Debarked logs are rough sawn to approximate size. Most rough cut lumber is dried in kilns while some is air dried. The dried lumber is then planed to final dimensions. Wood preserving plants typically obtain such lumber from sawmills and pressure treat it with preservatives to produce products such as decking and construction lumber.

Debarked logs may be used for round preserved wood products such as poles, pilings, or fence posts and rails. Manufacture of these products requires milling, drying, and pressure application of preservatives.

Both biomass and fossil fuel sources of energy are used in the manufacturing processes. Wood drying is the most energy intensive process. By-product wood biomass (sawdust, peeler shavings, etc.) is the primary source of energy needed for drying. Natural gas provides the remaining industry-required energy for drying. Electricity from the grid is used throughout the manufacturing process, powering saws, fans, pumps, planes, lights, and other equipment. Diesel fuel is used for most product transportation. The manufacture of wood preservatives also requires inputs of fossil fuel and other resources. Thus, manufacturing results in releases of CO₂ from both biogenic and fossil sources.

3.4. Service Life

Preserved wood products are used where protection from potential for decay, insect attack, or fire is needed. Service life continues until the product degrades to the point that it must be replaced, such as for utility poles or railroad ties, or until the entire structure is torn down or replaced, such as a deck, bridge, or building. Outdoor decking may have a service life from five³ to 30 years, utility poles from 15⁴ to nearly 100 years, and railroad ties from 10⁵ to 60 years. Service life depends on factors including the exposure environment, applied loads, product quality, maintenance, and user preferences.

³ Typically a result of home improvements that result in deck removal and not due to product failure.

⁴ Typically a result of road widening projects and not product failure.

⁵ Typically a result of track realignment and not product failure.

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Preservative application limits, but does not prevent, eventual degradation. Over time, some of the wood mass is converted to CO₂ due to chemical oxidation, decay, and/or insect damage. This end-of-life management analysis assumes that 5 percent of the wood mass is converted to CO₂ over the service life. Thus, most carbon in the preserved wood product is stored in the product until the end of its service life.

3.5. End-of-Life Management

3.5.1. Options for Disposition

Following primary service, preserved wood products are removed. The primary options for disposition of those products include reuse for other preserved wood applications, reuse as fuel or ingredient to produce energy, or disposal in landfills.

3.5.2. Reuse

Following primary service use, products that are still sound may be used for other, less demanding purposes. Weathered decking may be used for a raised bed garden. Railroad ties may be used for retaining walls. Utility poles may be used for fence posts or parking bumpers. Reuse extends the overall service life of the preserved product. Some of the wood installed in these secondary uses may never be removed, but simply decay in place in or near the secondary use location. Some used products will be removed when no longer suitable for service and disposed in landfills. Reuse for energy at this point is uncommon and assumed not to occur.

3.5.3. Reuse for Energy

The energy input from the sun, during photosynthesis, may be recovered if the wood mass is used for energy production. Typically, this is done through combustion, releasing the energy as heat. Processes such as gasification or fermentation may use the wood as an ingredient to produce gaseous or liquid biofuels, such as syngas, methane, or ethanol. Such reuse adds further value to the preserved wood life cycle and offsets fossil fuel that would otherwise have been used for the same purpose.

3.5.4. Landfill Disposal

Preserved wood may be disposed in landfills. Modern landfills require significant, energy intensive, construction inputs; including excavation and land shaping of the disposal cells, and in

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most cases, installation of polyethylene and/or clay liners, and leak detection systems. At closure, landfills require covers, and may require landfill gas collection systems and long term monitoring. Organic material in landfills decays anaerobically. USEPA estimates that approximately 23 percent of wood mass will decay with the remainder “sequestered” or stored in the landfill.

AquAeTer has developed an EPA-based landfill model that predicts 77 percent of the wood carbon is stored long-term, and, depending on the mix of landfill types in use, approximately 17 percent and 6 percent of the wood carbon will be released to the atmosphere as biogenic carbon dioxide and methane, respectively. Considering that methane is estimated to have 21 times the global warming impact of CO₂, the 6 percent methane is equivalent to 126 percent of the original wood carbon. Of the 100 percent of CO₂ removal by the tree growth, 143 percent (126 percent + 17 percent) of its GHG equivalent is returned to the atmosphere (prior to consideration of the ancillary process using fossil fuels to get the wood products into the market). Thus, for wood that is disposed in landfills and not considering other processes that credit the use of wood products, the net GHG emission, as CO₂-equivalent, is approximately 1.4 times the GHG removed by growth of that wood.

3.5.5. Life Cycle Comparison of End-of-Life Options

AquAeTer prepared a simplified life cycle inventory (LCI) to model end-of-life alternatives for preserved wood. The LCI is cradle-to-grave in scope, including tree planting and growth, harvest and milling, drying, preservative application, service life, and optional disposition scenarios.

The LCI model quantifies estimated inputs to and outputs from each process involved in the cradle-to-grave life cycle of representative preserved wood products. The main processes are estimated by use of factors downloaded from the U.S. Department of Energy, National Renewable Energy Laboratory (NREL) U.S. Life Cycle Inventory (LCI) Database, including electric energy, natural gas and oil production and combustion, wood combustion, and transportation. Life cycle process inputs and outputs are calculated. Forestry related inputs and outputs for southeastern and northwestern softwood log production, from NREL, are weighted and an average mix of wood sources is calculated. Supporting data related to wood properties

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are included in Appendix 3. Calculations, related to combustion energy and efficiency of wood biomass, are included in an LCI summary table in Appendix 4. The detailed LCI spreadsheet is available upon request.

The result of the LCI is the total greenhouse gas impact (including additions to and removals from the atmosphere) from a representative 1,000 cubic feet (Mcf) of preserved wood summed to the end of each life cycle stage. The end-of-life scenarios are summarized in Table 4.

The life cycle stages are:

- Plant & Forestry – Seedling start and planting in the forest.
- Harvested Log - “Typical” log cut from forest, with bark, at the sawmill.
- Dry Untreated Wood – Wood cut from debarked logs, dried, and finish planed with biomass partially used to offset natural gas use.
- Preserved Product – Wood treated with preservative at preserving plant, including preservative manufacture.
- Service Life - Preserved wood used for intended purpose with minimal decay or wood loss.
- Disposition Options – Following primary service, the most significant processes involved in disposition include:
 - Reuse for Energy – Reuse of preserved wood as biomass for energy production resulting in wood carbon being released as CO₂ emission.
 - Energy Offset – The emissions that would have resulted from fossil fuel use if the biomass energy recovery had not occurred. Modeled as negative grid electricity use.
 - Second Use Decay – Portion of preserved wood reused for other purposes and which will decay in place. Decay converts wood carbon to release of CO₂.
 - Landfill Decay – The greenhouse gas equivalent value of CO₂ and methane released from landfills due to decay.
- Total Life Cycle – The final “grave” endpoint of the life cycle.

• **Table 4 - End-of-Life Scenarios**

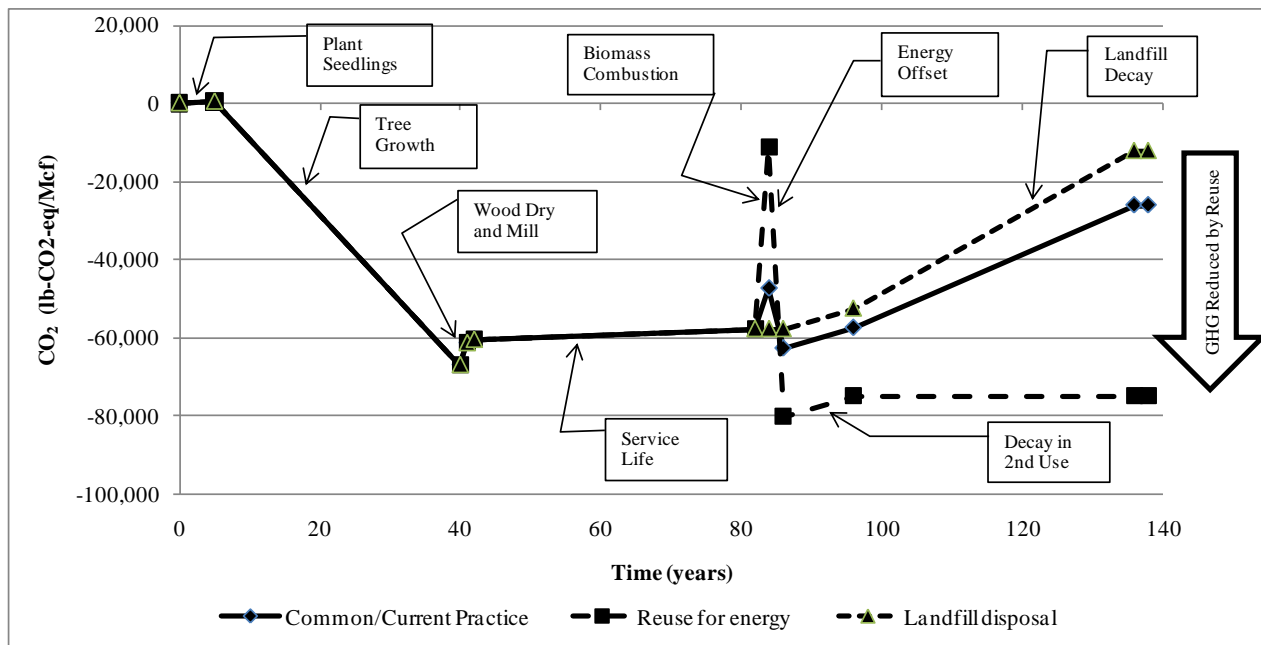
End-of-life option	Common/Current Practice	Reuse for energy	Landfill disposal
Scenario No.	1	2	3
Secondary use with decay in place	10%	10%	10%
Reuse to energy	20%	90%	0%
Landfill disposal	70%	0%	90%

The total cradle-to-grave GHG balance, including contributions and credits from both fossil and biogenic sources is presented in Figure 1. The GHG balance is presented in units of pounds of CO₂-equivalent per Mcf of preserved wood. Sawdust and other by-products from milling are used for energy, resulting in energy offsets. Following service life, each of the three disposition

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scenarios are tracked separately. The baseline represents approximately the average mix of disposition choices currently applied to the overall preserved wood market. The reuse and landfill options represent the possible extremes of choices with all preserved wood going to one or the other disposition options so that differences can be highlighted. The reduction in GHG emissions associated with reuse of preserved wood for energy amounts to approximately 70,000 pounds of CO₂-eq. per Mcf of preserved wood, compared to a reduction of approximately 10,000 pounds under the landfill scenario⁶. The difference between the two options is highlighted by the arrow on the right side of Figure 1.

Figure 1 – Total (Biogenic and Fossil) GHG Balance for Preserved Wood



All scenarios result in some net reduction, rather than increase, of GHG over the life cycle. The reduction results from GHG accounting that provides offset credits for the beneficial use of by-product bark and sawdust for process heat and energy production equal to the emissions that would have resulted from equivalent fossil fuel use. Also, landfill methane capture is included as an energy credit.

⁶ Note that the final value for the landfill scenario is less than zero. While this may seem contrary to the discussion of landfill carbon balance in Section 3.5.4, the result includes a 50% fraction of the 20% of log mass removed during milling (bark and peeler shavings) used as boiler fuel, replacing combustion of natural gas. Additional reduction for landfill disposal results from use of collected methane to offset natural gas combustion.

4. ENERGY REUSE CONSIDERATIONS

4.1. Chemicals in Preserved Wood

The compositions of specific wood preservative systems are included in Appendix 3. The following sections provide data, by wood preservative type, demonstrating the appropriateness for combustion of preserved wood as fuel in properly designed and permitted combustion facilities.

4.1.1. Creosote-Preserved Wood

Creosote has been used as a preservative for over 100 years. Creosote is derived from coal tar, an EPA recognized “traditional fuel⁷”, produced by condensing organic vapors from baking coal in ovens at high temperature in the absence of oxygen to make coke. Creosote is produced from coal tar by fractional distillation, similar to production of diesel oil from crude oil. Creosote is a hydrocarbon composed mainly of carbon (about 80 percent) and hydrogen, similar to petroleum products. However, creosote differs by being composed mostly of polycyclic aromatic hydrocarbon (PAH) compounds, meaning the molecules are groups of carbon-hydrogen benzene rings rather than linear chains of carbon and hydrogen. Like petroleum oil, creosote has high fuel value at approximately 15,000 BTU/pound.

Concern about burning creosote preserved wood for energy relates to the thought that PAH compounds of creosote may be emitted. While a valid concern for open burning with poor combustion control, test data document that PAH emissions, from creosote-preserved wood burned in industrial or commercial boilers, are minimal. In fact, because used creosote-preserved wood is typically drier than green biomass fuel and because it contains approximately 5 to 10 percent creosote, creosote-preserved wood burns hotter and with less emissions of PAH and other products of incomplete combustion (PICs) than “clean” biomass, as further detailed in test data presented below.

⁷ Traditional fuel is defined by USEPA as cellulosic biomass (e.g., wood) and fossil fuels (e.g., coal, oil, natural gas) and their derivatives (e.g., petroleum coke, bituminous coke, coal tar oil, refinery gas, synthetic fuel, heavy recycle, asphalts, blast furnace gas, recovered gaseous butane, coke oven gas) that have been burned historically as fuels and have been managed as valuable products.

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A stack test of a biomass boiler in Mississippi (Smith 1996), burning a 50/50 mixture of creosote-preserved and pentachlorophenol-preserved wood demonstrated in both low and high fire conditions that total PAH emissions are less when burning preserved wood than when burning green wood. The study is significant since the boiler had only simple cyclone type particulate emission control. The findings of the study are summarized in Appendix 5.

In a separate report, PAH emissions from two industrial facilities burning 25 percent to 50 percent and 20 percent used crosstie fuel mixed with untreated wood biomass fuel were documented. The study found that PAH emissions from combustion of only untreated wood fuel compared to combustion of a mixture of preserved and untreated wood that emission rates varied between facilities, rather than between fuels, indicating that combustion conditions and emission control equipment were the primary factors related to PAH emissions (Holtzman and Atkins, 1995). Therefore, out-of-service creosote-preserved wood can be used as an energy recovery fuel in a properly designed and permitted combustion facility.

4.1.2. Pentachlorophenol-Preserved Wood

The stack test completed in Mississippi (Appendix 5) documented that greater than 99.99 percent of pentachlorophenol (penta or PCP) is effectively destroyed by combustion in a conventional wood fired boiler. Up to approximately 50 percent of the chlorine in the fuel was emitted as hydrochloric acid (HCl). Typical emissions, in today's boilers, are expected to be lower since flue gas acid treatment technologies, such as scrubbers, remove HCl.

Penta combustion need not cause emissions of polychlorinated dibenzodioxins and dibenzofurans (PCDD/DF's). A study for the USEPA tested emissions from a boiler co-firing wood biomass with penta and creosote wastes (DeRos et al, 1982). "No CDF or CDD were detected in the air emissions." The California Air Resources Board determined, based on the above and other studies, that "...the results indicate quite strongly that when combusted with sufficient oxygen and at a low enough concentration of PCP in the fuel, PCDDs and PCDFs are not emitted from small-scale combustion of preserved wood wastes in industrial boilers using modern pollution control equipment such as bag-houses and precipitators."

PCDD/DF's result as products of incomplete combustion (PICs) with chlorine in included in combustion fuel. USEPA's National Dioxin Study (Rand Corporation, 1986) notes that PCDD

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emissions from coal combustion increased with the addition of chlorine. The study further states; “In order to destroy PCDD’s or prevent their formation, the combustion efficiency must be high. This requires a combination of high temperatures, available oxygen, high heating value fuel, and long residence times.” These same conditions are required for efficient combustion of most conventional solid fuels. Therefore, penta-preserved wood can be used as an energy recovery fuel in a properly designed and permitted combustion facility.

4.1.3. Water-borne Preserved Wood Containing Arsenic, Chromium, and/or Copper

Data from a report that reviewed fuel and emissions data for clean (untreated) wood, creosote and penta preserved wood, and C&D wood waste (Holtzman and Atkins, 1995) is used to calculate emissions of metals relative to metals in the input fuel. The facilities studied are relatively modern and included electrostatic precipitator or fabric filter controls. Select data are entered and calculations completed in Appendix 6. The calculations demonstrate 99.9 percent to 100 percent control of arsenic, chromium, copper, and lead for emissions relative to feed rates. Thus, approximately 99.99 percent of metals from preserved wood remain with the ash waste stream. Resulting emissions are generally similar to those for conventional fuels. Constituents in fuels are not contaminants if they are not emitted when the preserved wood is burned as fuel. Such preserved wood, when combusted in an appropriate and permitted facility, can be used as an energy recovery fuel.

4.1.4. Water-borne-Preserved Wood Containing Copper

Newer water-borne preservative formulations, such as alkaline copper quaternary (ACQ) and copper azole, utilize copper as the primary active ingredient mixed with low concentration carbon based co-biocides. As noted above, very little if any of the copper is emitted and the carbon-based components are destroyed by combustion. Further, neither copper nor the carbon-based biocides are hazardous air pollutants. Therefore, copper-preserved wood can be used as an energy recovery fuel in a properly designed and permitted combustion facility.

4.1.5. Copper Naphthenate-Preserved Wood

Copper naphthenate preservative consists of copper dissolved in naphthenic acid. The preservative is diluted in diesel oil to treat industrial products such as utility poles and bridge timber. It may also be diluted in mineral spirits or be prepared in a water-borne formulation for

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pressure application or for use as a field applied treatment. Naphthenic acid is a by-product of crude oil distillation and is a hydrocarbon, with fuel value. When copper naphthenate preserved wood is burned, most of the copper, which is not a hazardous air pollutant, is expected to remain with the ash while the carbon-based constituents are destroyed by combustion. Therefore, copper naphthenate-preserved wood can be used as an energy recovery fuel in a properly designed and permitted combustion facility.

4.1.6. Preservatives Containing Boron

Wood preserved with water-borne preservative or fire-retardant solutions, including boron or borates, are commonly used in building construction. Some are stained to identify the wood product as preserved, but the preservative itself does not impart color. Thus, identifying wood that is protected with boron may be difficult. A recent trend for railroad ties is to pre-treat the wood ties with water-borne borate solution and then to treat with creosote. This has been shown to provide significant performance improvement for ties installed in high decay hazard locations.

Boron in wood does not interfere with wood combustion and is not expected to impact emissions. A study of emissions resulting from combustion of various preserved wood fuels, including boron treatments, concluded that “Very good combustion properties were also found for ...[boron preserved wood]”(Salthammer, Klipp, Peek, and Marutzky, 1994). The test data emissions of carbon monoxide and NO_x were of similar or lower levels for boron containing wood fuel than for untreated wood fuel. Boron is not listed in the CAA 112(b) as a hazardous air pollutant. Therefore, borate-preserved wood can be used as an energy recovery fuel in a properly designed and permitted combustion facility.

4.2. Issues of Lumber and “Industrial” Markets

The issues, related to the collection and utilization of preserved wood at disposition, are quite different between the conventional lumber markets and the “industrial” markets. Industrial products, such as utility poles, railroad ties, piling, or transportation structures, generally are used and managed by larger companies or governments. These organizations often have policies and procedures governing recycling and waste disposal. Many have procedures in place to collect used preserved wood products when removed from service and to use the product as a valuable

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commodity, usually as fuel. Such materials typically do not enter the conventional “waste stream” and are not diverted for reuse.

Preserved lumber is used by a wide and diverse group of people and companies. Its primary uses include decks, fences, and sill plates and/or building framing (depending on locations). When removed from service, the preserved lumber product is likely disposed by the home or building owners or their contractors as municipal or construction-demolition waste. The likely route to reuse for energy is through waste sorting or recycling centers, where materials of fuel value are separated and marketed as fuel.

While the potential value and benefits for use of preserved wood products as fuel are real, so are economic and regulatory difficulties. Used preserved wood products often include nails or heavy steel hardware, may be attached to other materials, such as sheetrock, and may be painted or stained. These products are generally large or randomly sized and awkward to handle. Use as fuel generally requires separation of steel and incombustible materials, grinding or chipping to acceptable fuel size, and transportation and use by facilities with the appropriate combustion and control equipment and permits.

Regulation, that awards economic value to biomass as a renewable fuel offsetting fossil fuel CO₂ emissions, encourages facility owners to install equipment and obtain permits needed to use preserved wood as fuel. Regulations that classify used preserved wood as waste rather than as fuel or specifically ban the use of preserved wood as a fuel source, prevent this beneficial use.

Thus, to realize the full potential of preserved wood utilization for energy, laws and regulations should be revised to remove disincentives and bans on, while also expanding incentives for, beneficial reuse of treated wood.

4.3. Energy Recovery Technologies Reviewed

4.3.1. Combustion Systems

The most common means of recovering useful energy from biomass or fossil fuels is combustion. Generally, solid fuel, such as wood, is reduced in size, ranging from large chunks down to small chips. The fuel is burned in combustion systems with air (oxygen) to support efficient combustion. Emissions controls vary according to combustor type, fuel types, local

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requirements, and facility size, but usually include particulate controls, such as cyclones. Larger systems typically include electrostatic precipitators or scrubbers. Emission controls are normally required as part of the facility operating permits.

Most combustion units are part of boilers, in which the hot gas heats water to provide steam and/or hot water for other processes. Some combustion units are part of direct fired heating equipment. In these units, hot combustion gas directly heats a process, such as to dry lumber in a kiln.

Power generation boilers are units used only to turn a turbine to make electricity. Boilers that make secondary use of the steam heat, such as first running high pressure steam through a turbine for electric energy and then low pressure steam to process heating, are considered cogeneration or combined heat and power facilities. Cogeneration allows plants to achieve higher thermal efficiency than with power production alone.

Wood or preserved wood fuel may be burned alone, as the sole source of energy to a facility, or in combination with other fuels. For example, preserved wood may be burned with coal in some units.

The main issue regarding use of preserved wood as fuel in combustion systems is that the combustion and control equipment must be designed to use the fuel provided and to meet any applicable emission control regulatory and permit requirements.

4.3.2. Cement Kiln Fuel

Cement kilns utilize fuel in a rotating, sloped, cylinder in which limestone is added in the upper end and is converted to clinker by exposure to high temperature as it tumbles to the lower end to be discharged. Fuel and air are mixed and combusted at the lower end with the hot gas in counter-flow to the limestone feed causing reactions to occur between the combustion gases and the limestone. Most metals become bound to the clinker product, rather than being emitted. Kiln exhaust typically is routed through emission control equipment to further limit emissions. Thus, preserved wood can be used as a biomass fuel in cement kilns that include the appropriate combustion and control equipment and permits.

4.3.3. Gasification

Gasification is a process in which the preserved wood and/or other solid fuel are heated to over 700°C with limited oxygen and steam. A portion of the biomass burns to heat the gasification process. The gas product, called synthesis gas or syngas, is a mixture mainly of carbon monoxide and hydrogen. Syngas is burned as a fuel or converted through chemical processes to synthetic fuel, such as ethanol or biodiesel.

New commercial biomass gasification plants are under construction and others are in planning. For example, Enerkem is now completing a commercial scale biofuels plant in Westbury, Ontario that is producing syngas from preserved wood utility poles and will this year begin production of ethanol. A larger waste-to-ethanol plant is planned for Edmonton, Alberta. A planned waste-to-biofuel plant to be built in Pontotoc, Mississippi, will accept 190,000 tons of unsorted municipal solid waste per year. Approximately 10 million gallons of ethanol and other waste-to-product chemicals will be produced annually. The Mississippi project has been selected to receive \$50 million from the U.S. Department of Energy. In these cases, alternative fuels will be produced from the processing of secondary materials. A portion of the secondary material likely will be preserved wood. If preserved wood were required to be separated from other wood in the municipal waste stream, higher costs, less fuel, more landfill space, and more methane GHG emission would result.

4.3.4. Energy Recovery Conclusion

Wood preserving chemicals should not drive issues in determining if a preserved wood product is reused for energy. The appropriate matching of combustion and control conditions and equipment to the fuel being used affects emission levels.

4.3.5. Preserved Wood to Energy Facilities

To the authors knowledge, there are no industry data available estimating the amount of preserved wood diverted from landfills and sent for energy recovery. The disposition of such preserved products is based on the entity handling final disposition and the availability of disposition options.

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A list of facilities in North America that will accept preserved wood to be used for energy is included in Appendix 7. This list does not include all wood to energy facilities and the status of facilities on the list is subject to change.

4.4. Benefits of Energy Recovery

The national implications of reusing preserved wood for energy as an end-of-life management option, instead of landfill disposal, can be estimated by use of national preserved wood volume production data, fuel value data, and life cycle results. A model of these implications is included in tables within Appendix 3.

The energy contained in the annual turnover of 640 million cubic feet preserved wood is equivalent to approximately 32 million barrels of oil. If preserved wood products are beneficially reused for energy, the energy could offset the fossil fuel requirement of approximately 646,000 U.S. citizens or about 0.21 percent of total U.S. fossil fuel requirement (calculations detailed in Appendix 3).

Since the CO₂ emissions from wood, a biogenic fuel, are neutral regarding GHG emission impacts, use of this fuel reduces GHG compared to use of equivalent amounts of fossil fuel. The offset to GHG associated with the full utilization of 640 million cubic feet of preserved wood per year would be equal to the annual per capita emissions of approximately 868,000 U.S. citizens or about 0.29% of the U.S. total GHG output (calculations detailed in Appendix 3).

The impact on U.S. landfill capacity is large. Disposal in landfills of 640 million cubic feet per year of preserved wood would equate to approximately nine percent of annual U.S. landfill use or the equivalent disposal of approximately 28 million U.S. citizens.

5. CONCLUSIONS

The beneficial reuse of preserved wood products as a non-fossil source of energy, following primary service life, is currently underutilized. Although many preserved wood products are being reused for energy, such as combustion systems, kiln fuel or gasification, significant increased market reuse of treated wood products is possible.

Preserved wood of various preservative types is widely used in the U.S. A current estimate of annual preserved wood production is 640 million cubic feet. If all 640 million cubic feet is disposed in landfills, the volume is equivalent to approximately nine percent of total U.S. landfill disposal volume (calculations detailed in Appendix 3).

Utilization of the preserved wood after its service life offers substantial potential benefits. The preserved wood has energy value to offset the use of approximately 32 million barrels of oil annually, the equivalent fossil fuel usage of approximately 646,000 people or 0.21 percent of the total U.S. fossil fuel annual consumption.

Utilization of preserved wood for energy also results in lower U.S. GHG emissions. If all 640 million cubic yards of preserved wood were used for energy recovery, the GHG reduction would be equivalent to approximately the GHG emissions from 868,000 U.S. citizens or roughly 0.29 percent of U.S. total GHG emissions.

Studies have shown, as detailed in this assessment, that emissions from the use of preserved wood in combustion and other energy recovery systems are generally the same or lower than from untreated wood biomass combustion, assuming the preserved wood is used in facilities with the appropriate combustion and control equipment, permits, and procedures.

Exploiting the end-of-life value of preserved wood would thus provide an expanded energy source while lowering GHG emissions and reducing landfill requirements. Federal, State, and regional governments and agencies should encourage and reward beneficial reuse of preserved wood following its removal from service. Recommended actions toward this end include:

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- Include preserved wood that has been removed from service within the definition of “biomass” in any laws or regulations. Any incentives used to encourage use of renewable biomass, at approved or permitted facilities, should apply equally to preserved wood biomass.
- Repeal laws that hinder, prevent, or ban the use of preserved wood for energy.
- Do not pass laws that would regulate preserved wood removed from service.

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APPENDIX 1 PRESERVATIVE SYSTEMS OVERVIEW

Various water-borne and oil-borne wood preservative systems are in common use in the U.S. market today. The following presents a brief overview of the more common systems.

1. Chromated Copper Arsenate (CCA)

For most of the last half century, any “treated lumber” was preserved with CCA. Since 2003, the industry has transitioned to alternative treatments for residential and commercial lumber uses, such as decking. CCA continues to be used for the “heavy duty” applications such as agricultural posts, transportation structures, utility poles, and foundation and marine piling. CCA preserved wood is generally green, but decking lumber is often stained to brown or “cedar” color.

Due to the transition from CCA for residential uses, the volume of CCA preserved lumber being removed from service is expected to drop significantly over the next decade (Smith, 2005).

AWPA P5-09, Section 6, states the following regarding the composition of CCA-C, the formulation currently in use:

6.1 The active ingredients in chromated copper arsenate shall have the following composition on a 100% oxide basis:

<i>Hexavalent chromium, as CrO₃.....</i>	<i>47.5%</i>
<i>Copper, as CuO.....</i>	<i>18.5%</i>
<i>Arsenic, as As₂O₅</i>	<i>34.0%</i>

CCA retentions for typical products include:

- Sawn lumber 0.6 pcf
- Utility poles 0.6 pcf
- Marine piling 0.8 to 1.0 pcf

2. Ammoniacal Copper Zinc Arsenate (ACZA)

ACZA preservative is used for “heavy duty” applications, like CCA, except that it is primarily used in the Western U.S. to preserved Douglas fir, which is difficult to treat with CCA. ACZA preserved wood tends to exhibit a blue-green color.

AWPA P5-09, Section 3, states the following regarding the composition of ACZA:

3.1 Ammoniacal Copper Zinc Arsenate shall have the following composition:

<i>Copper as CuO.....</i>	<i>50.0%</i>
<i>Zinc as ZnO</i>	<i>25.0%</i>

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Arsenic as As₂O₅ 25.0%

ACZA retentions for typical products include:

- Sawn lumber 0.25 pcf
- Utility poles 0.6 pcf
- Marine piling 1.5 to 2.5 pcf

3. Alkaline Copper Quat Type D (ACQ-D)

ACQ is primarily used for residential and commercial lumber to be used outdoors without or with ground contact. Preserved wood is generally green, but may be pre-stained for a cedar color.

AWPA P5-09, Section 14, states the following regarding the composition of ACQ-D:

14.1 ACQ Type D shall have the following composition:

Copper, as CuO 66.7%
Quat, as DDAC 33.3%

The standard further states that the copper will be dissolved by addition of ethanolamine at 2.75 times the weight of the copper oxide in the solution. The “quat” refers to quaternary ammonium compounds.

ACQ-D retentions for typical products include:

- Sawn lumber for decks and fences 0.15 to 0.6 pcf

4. Copper Azole Type C (CA-C)

CA-C is also primarily used for residential and commercial lumber for outdoor use with or without ground contact. It is typically a green color and may also be prestained cedar color.

AWPA P5-09, Section 24, states the following regarding the composition of CA-C:

24.1 Copper Azole Type C shall have the following composition:

Copper as Cu.....96.1%
Azole as Propiconazole.....1.95%
Azole as Tebuconazole.....1.95%

CA-C retentions for typical products include:

- Sawn lumber for decks and fences 0.06 to 0.15 pcf

5. Micronized Copper

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Formulations of water-borne preservatives, similar to ACQ and CA, described above, have been introduced over approximately the last five years that include very small copper particles in suspension, rather than as dissolved copper. A common form of copper is copper carbonate. While no emission test results from combustion of micronized copper preserved wood are known, the high density of copper, its high vaporization temperature, and its tendency to bind to other materials within the ash matrix lead the authors to predict no difference in emissions than for other copper based wood preservatives.

6. Creosote

Creosote is the original industrial wood preservative. It has been used to preserve railroad ties for over 100 years. Creosote is a by-product from the distillation of coal tar which is a by-product from production of coke from coal for steel making. Thus, the composition of creosote is derived from coal. Creosote is a complex mixture of hydrocarbons.

Creosote is used for heavy duty industrial products such as crossties, poles, and piling. The preserved wood will have a brown to black color and distinctive “mothball” smell. Several creosote formulations are standardized by AWWA; P1/P13 for creosote preservative, P2 for creosote solution, and P3 for creosote-petroleum solution. From the perspective of end-of-life management, there is little difference between these formulations.

Unlike the water-borne preservatives described above, creosote preservative has fuel value and has a higher heat value compared to untreated wood.

Creosote retentions for typical products include:

- | | |
|---|--------------------------------|
| • Sawn lumber for transportation structures | 8.0 to 12 pcf |
| • Railroad crossties | 7.0 to 8.0 pcf (or to refusal) |
| • Utility poles | 6.0 to 20 pcf |
| • Marine piles | 16 to 20 pcf |

7. Pentachlorophenol

Pentachlorophenol (penta) is mixed with petroleum oil to make the preservative solution. Thus, it is “oil borne.” Like creosote, it is used for heavy duty outdoor applications, primarily utility poles.

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Preserved wood is generally a light to dark brown, slightly darker than untreated wood and similar in color to wood wet with water. Its presence may be detectable by smell.

AWPA standard P8-09, Standard for Oil-Borne Preservatives, Section 1, covers pentachlorophenol.

Penta retentions for typical products include:

- Sawn lumber for transportation structures 0.4 to 0.6 pcf
- Utility poles 0.3 to 1.0 pcf

8. Copper Naphthenate

Copper naphthenate is also an oil-borne preservative solution. Copper is dissolved in naphthenic acid and most often diluted with fuel oil to preserve industrial products, such as bridge timbers and utility poles. Copper naphthenate preservatives are also commercially available for field application in both water and solvent based solutions.

AWPA standard P8-09, Standard for Oil-Borne Preservatives, Section 2, covers copper naphthenate. Copper naphthenate retentions for typical products include:

- Sawn lumber for transportation structures 0.06 to 0.075 pcf
- Utility poles 0.06 to 0.13 pcf

Copper naphthenate preserved wood typically is of a green tone, but color will vary depending on the carrier, other stains, and age.

9. Fire Retardant

AWPA lists two standards for fire retardant treatments, both of which are limited in interior applications where frequent wetting by rain is prevented. AWPA P49-10, Standard for Fire Retardant FR-1 has the following composition:

- Guanylurea Phosphate 70% avg wt/wt
- Boric Acid 30% avg wt/wt

AWPA P50-10, Standard for Fire Retardant FR-2 has the following composition:

- Phosphate as P_2O_5 57.8% avg wt/wt
- Boric Acid as H_3BO_3 18.3% avg wt/wt
- Ammonia as NH_3 23.9% avg wt/wt

**APPENDIX 2 ESTIMATED ANNUAL PRODUCTION OF PRESERVED WOOD BY
PRODUCT TYPE AND REGION**

Estimate of Production Based on Historical Data

Product	Creosote (1,000 cf)	Oilborne (1,000 cf)	Water-borne (1,000 cf)	All Preservatives (1,000 cf)
Actual Production Values by Product and Preservative Type (1997 AWPI Survey Data)				
Crossties	75,939	0	0	75,939
Switch and bridge ties	5,920	0	68	5,988
Poles	9,421	31,972	23,128	64,521
Crossarms	2	2,374	49	2,425
Piling	1,343	0	7,678	9,021
Fence posts	500	544	14,061	15,105
Lumber	1,026	421	383,892	385,339
Timbers	1,450	53	84,516	86,019
Specialty products	0	0	18,906	18,906
Landscape timbers	3	3	20,713	20,719
Plywood	0	0	19,345	19,345
Other products	1,785	476	9,026	11,287
Summary of All Products (based on 1997 AWPI Survey Data)	97,389	35,843	581,382	714,614
Total Production Estimate (average from 1996, 1997, 2004)				638,977
Estimate of Current Production by Preservative Type	87,081	32,049	519,847	638,977

Production of Preserved Wood in the U.S. By Region, 1997

Region	Number of Plants	Percent of Total
Northeast	44	8.50%
Northcentral	81	15.74%
Southeast	135	28.42%
Southcentral	122	31.74%
Rocky Mountain	23	3.10%
Pacific Coast	40	12.50%
All Regions	445	100%

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APPENDIX 3 PROPERTIES OF WOOD SPECIES, ENERGY OFFSET, AND VOLUME COMPARISON

Treated Wood Components	Untreated	Creosote	Oil-borne	Water-borne	Total
Typical wood species	Softwood biomass (Southern pine)	Hardwood (avg oak)	20% Douglas fir & 80% Southern pine	Southern pine	
Wood (dry mass) (lb/ft ³)	31.72	35.18	30.99	31.72	
Moisture content (avg)	50%	20%	20%	20%	
Water (lb/ft ³)	15.86	7.04	6.20	6.34	
Preservative (lb/ft ³)	0	3.94	1.25	0.46	
Complete density (lb/ft ³)	47.58	46.16	38.44	38.52	
Wood fraction of dry total	100.0%	89.9%	96.1%	98.6%	
Preservative components (lb/ft ³)					
Creosote		3.94			
Pentachlorophenol			0.15		
Fuel oil			1.1		
Copper and/or other inorganic				0.2	
Water heat of vaporization	1,000	1,000	1,000	1,000	
Preservative heat (BTU/lb)		15,000	477	0	
Oil heat (BTU/lb)			18,557		
Dry wood heat (BTU/lb) (AP42)	9,000	9,000	9,000	9,000	
Product heat (BTU/ft ³)	269,636	368,720	272,730	279,152	
Product heat (BTU/lb)	5,667	7,988	7,095	7,247	
Using the data above to conclude:					
Potential heat (MMBTU/yr)		32,108,552	8,740,812	145,116,444	185,965,808
Fuel oil heat (BTU/bbl)			5,880,000		
Fuel oil equivalent (MMbbl/yr)		5	1	25	32
U.S. fossil fuel (MMBTU/capita)			288		
Population offset		111,565	30,371	504,224	646,159
Offset (% of U.S. total)					0.21%
Comparison of landfill to recycle (Net CO₂-eq emission (tonne CO₂-eq))					
All preserved wood to landfill		276,448	101,744	1,650,307	2,028,499
All preserved wood recycled to energy		-2,527,523	-930,228	-15,088,523	-18,546,274
Difference		2,803,970	1,031,972	16,738,830	20,574,773
Population offset		118,275	43,530	706,064	867,869
Offset (% of U.S. total)					0.29%

Data used to calculate population offset above

GHG (CO ₂ -Eq) (USEPA 2009)	7,150.1	million metric tons
	15,765,970,500,000	lb-CO ₂ -eq/yr
	52,274	lb-CO ₂ -eq/yr/capita
US 2007 Population (EIA 2008):	301,600,000	

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Volume Comparison

	Creosote	Oilborne	Waterborne	Total
Annual Volume (Mcf)	87,081	32,049	519,847	638,977
Disposal mass (tons)	2,009,872	615,993	10,012,580	12,638,445
Height of stack on football field (ft)	1,512	556	9,025	11,093
Height of stack on football field (mile)	0.29	0.11	1.71	2.10
% of U.S. annual landfill use	1.5%	0.4%	7%	9%
Population offset	4,424,653	1,356,084	22,042,293	27,823,029

Data used to calculate volume comparisons

Football field dimensions	360	ft long
	160	ft wide
Football field area	57,600	ft ²
One mile =	5280	ft
US landfill use (2007)	137,000,000	tons/yr
US 2007 Population (EIA 2008):	301,600,000	
	0.45	tons/yr/capita

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APPENDIX 4 LIFE CYCLE INVENTORY OF PRESERVED WOOD

	Process:	Total Avg Barky Log Produced	Produced Dry Lumber	Produced Treated Lumber	Treated Wood at End of Service	Avg 2nd Use Process	Avg Reuse for Energy Process	Avg Landfill Process	Avg End of Life Processes	Treated Wood Full Life Cycle
	Production Amount:	1,250	1,000	1,000	1,000	100	200	700	1,000	1,000
	Production Units:	ft3	ft3	ft3	ft3	ft3	ft3	ft3	ft3	ft3
Inputs and Outputs										
Inputs from technosphere										
Electricity- Avg. US Grid	kWh	1.3E+01	8.7E+02	1.2E+03	1.2E+03	0.0E+00	-9.5E+03	4.3E+03	-5.2E+03	-4.0E+03
Natural gas, processed, at plant (feedstock)	ft3	5.2E+01	1.6E+03	7.0E+03	7.0E+03	0.0E+00	-1.7E+04	7.7E+03	-9.4E+03	-2.4E+03
Natural gas, combusted in boiler	ft3	1.4E+00	-6.9E+03	-5.3E+03	-5.3E+03	0.0E+00	-1.0E+03	-1.0E+04	-1.1E+04	-1.7E+04
Diesel fuel, at plant (feedstock)	gal	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Diesel fuel, combusted in boiler	gal	2.9E+01	2.9E+01	3.0E+01	3.0E+01	0.0E+00	-5.8E+00	2.6E+00	-3.2E+00	2.6E+01
LPG, combusted in equipment	gal	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Residual Oil, processed (feedstock)	gal	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Residual Oil, combusted in boiler	gal	9.0E-04	5.9E-02	8.1E-02	8.1E-02	0.0E+00	-6.5E-01	2.9E-01	-3.6E-01	-2.8E-01
Diesel fuel, combusted in equipment	gal	9.2E-01	-2.7E+01	-2.0E+01	-2.0E+01	0.0E+00	0.0E+00	-4.4E+01	-4.4E+01	-6.4E+01
Gasoline, combusted in equipment	gal	1.8E+00	1.6E+01	6.1E-01	6.1E-01	0.0E+00	-6.2E-01	-2.3E+00	-2.9E+00	-2.3E+00
Hogfuel/biomass (50%MC)	lb	2.7E+00	2.5E+03	2.6E+03	2.6E+03	0.0E+00	-5.8E+01	1.2E+02	5.8E+01	2.6E+03
Coal-bituminous & sub. comb in boiler	lb	3.5E+02	3.5E+02	3.5E+02	3.5E+02	0.0E+00	-2.6E+00	1.2E+00	-1.4E+00	3.5E+02
Coal (feedstock)	lb	3.4E+01	3.4E+01	3.4E+01	3.4E+01	9.4E-01	1.1E+01	7.3E+00	2.0E+01	5.3E+01
Energy (Unspecified)	Btu	3.7E+04	3.7E+04	3.7E+04	3.7E+04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.7E+04
Truck transport	ton-miles	3.2E+03	3.2E+03	3.2E+03	3.2E+03	8.9E+01	9.9E+02	7.4E+02	1.8E+03	5.0E+03
Rail transport	ton-miles	3.9E+01	1.9E+02	2.5E+02	2.5E+02	0.0E+00	-1.7E+03	7.8E+02	-9.5E+02	-7.0E+02
Barge transport	ton-miles	2.9E-01	1.9E+01	2.6E+01	2.6E+01	0.0E+00	-2.1E+02	9.5E+01	-1.2E+02	-9.0E+01
Ship transport	ton-miles	3.3E-01	2.1E+01	2.9E+01	2.9E+01	0.0E+00	-2.3E+02	1.1E+02	-1.3E+02	-1.0E+02
Inputs from nature										
Bark from harvest	ft3	1.1E+02	1.1E+02	1.1E+02	1.1E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E+02
Unprocessed coal	lb	7.4E+00	4.9E+02	6.7E+02	6.7E+02	0.0E+00	-5.3E+03	2.4E+03	-2.9E+03	-2.3E+03
Unprocessed U3O8	lb	1.9E-05	1.2E-03	1.7E-03	1.7E-03	0.0E+00	-1.4E-02	6.1E-03	-7.5E-03	-5.8E-03
Unprocessed crude oil	gal	3.3E+01	3.5E+01	3.6E+01	3.6E+01	0.0E+00	-2.0E+01	9.1E+00	-1.1E+01	2.5E+01
Unprocessed natural gas	ft3	2.9E+01	-7.1E+03	-6.1E+02	-6.1E+02	0.0E+00	0.0E+00	-1.1E+04	-1.1E+04	-1.2E+04
Biomass/wood energy	Btu	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Hydropower	Btu	3.5E+03	2.3E+05	3.1E+05	3.1E+05	0.0E+00	-2.5E+06	1.1E+06	-1.4E+06	-1.1E+06
Other renewable energy	Btu	2.6E+02	1.7E+04	2.3E+04	2.3E+04	0.0E+00	-1.9E+05	8.4E+04	-1.0E+05	-7.9E+04
Biogenic Carbon (from air)	lb	1.9E+04	1.7E+04	1.7E+04	1.6E+04	-1.4E+03	-2.8E+03	-2.8E+03	-7.0E+03	8.8E+03
GHG Outputs to nature										
CO2-Fossil	lb	1.7E+03	2.1E+03	2.9E+03	2.9E+03	2.3E+01	-1.5E+04	5.5E+03	-9.1E+03	-6.2E+03
CO2-Non-fossil	lb	-6.9E+04	-6.4E+04	-6.4E+04	-6.1E+04	5.2E+03	1.0E+04	7.9E+03	2.3E+04	-3.7E+04
Nitrous oxide (N ₂ O)	lb	3.9E-01	3.9E-01	3.9E-01	3.9E-01	5.7E-04	6.9E-03	4.5E-03	1.2E-02	4.0E-01
Methane	lb	1.0E+00	-2.1E-01	5.0E+00	5.0E+00	3.7E-04	-3.3E+01	8.5E+02	8.2E+02	8.3E+02
Impact Indicator										
GHG (CO ₂ -equivalent)	lb	-6.7E+04	-6.1E+04	-6.0E+04	-5.8E+04	5.2E+03	-5.0E+03	3.1E+04	3.2E+04	-2.6E+04

APPENDIX 5 1996 MISSISSIPPI BOILER STACK TEST RESULTS

Low Fire Scenario							
Fuel feed: 3,118 lb/hr							
Steam production: 10,050 lb/hr							
Constituent	Fuel Content	Constituent Feed Rate	Treated Fuel Emission	Untreated Fuel Emission	Treated Emission Increase	DRE (less background)	DRE (zero background)
PAHs	(mg/kg)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(%)	(%)
Naphthalene	724.8	2.26	4.321E-04	5.500E-04	-1.179E-04	100%	99.981%
Acenaphthylene	23	0.07	7.036E-06	1.600E-03	-1.593E-03	100%	99.990%
Acenaphthene	596.1	1.86	1.957E-05	7.700E-04	-7.504E-04	100%	99.999%
Fluorene	512.2	1.6	1.598E-05	1.500E-04	-1.340E-04	100%	99.999%
Phenanthrene	2121.7	6.62	8.735E-05		8.735E-05	99.999%	99.999%
Anthracene	546.8	1.7	9.309E-05		9.309E-05	99.995%	99.995%
Fluoranthene	1327.4	4.14	1.478E-05	1.160E-03	-1.145E-03	100%	100%
Pyrene	911.1	2.84	6.006E-06	7.700E-04	-7.640E-04	100%	100%
Benzo(a)anthracene	238.7	0.74	4.996E-06		4.996E-06	99.999%	99.999%
Chrysene	250.4	0.78	4.996E-06	1.500E-04	-1.450E-04	100.0%	99.999%
Benzo(b)fluoranthene	113	0.35	4.996E-06		4.996E-06	99.999%	99.999%
Benzo(k)fluoranthene	104.9	0.33	4.996E-06		4.996E-06	99.998%	99.998%
Benzo(a)pyrene	104	0.32	4.996E-06		4.996E-06	99.998%	99.998%
Dibenzo(a,h)anthracene	0.9	0.005	4.996E-06		4.996E-06	99.900%	99.900%
Benzo(g,h,i)perylene	21.3	0.07	4.996E-06		4.996E-06	99.993%	99.993%
Indeno(1,2,3-c,d)pyrene	25.4	0.08	4.996E-06		4.996E-06	99.994%	99.994%
Total PAH	7621.7	23.765	7.159E-04	5.150E-03	-4.434E-03	100%	99.997%
Chlorophenols							
Pentachlorophenol	211.6	1.55	2.498E-05		2.498E-05	99.998%	99.998%
Total chlorophenols	211.6	1.55	4.996E-05		4.996E-05	99.997%	99.997%
Other							
Hydrogen Chloride (HCl)	534.56	3.91	1.16		1.160E+00	70.332%	70.332%
Sulfur dioxide (SO ₂)	4800	35.13	1.84		1.840E+00	94.762%	94.762%

End-of-Life Management of Treated Wood

High Fire Scenario							
Fuel feed: 7,318 lb/hr							
Steam production: 29,600 lb/hr							
Constituent	Fuel Content	Constit. Feed Rate	Treated Fuel Emission	Untreated Fuel Emission	Treated Emission Increase	DRE (less backgd)	DRE (zero backgd)
PAHs	(mg/kg)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(%)	(%)
Naphthalene	974.1	7.13	6.72E-04	5.500E-04	1.224E-04	99.998%	99.991%
Acenaphthylene	34.9	0.26	7.17E-06	1.600E-03	-1.593E-03	100%	99.997%
Acenaphthene	739.4	5.41	7.72E-06	7.700E-04	-7.623E-04	100%	100%
Fluorene	618.4	4.53	6.72E-06	1.500E-04	-1.433E-04	100%	100%
Phenanthrene	2452.9	17.95	5.17E-05		5.174E-05	100%	100%
Anthracene	645.7	4.73	5.52E-05		5.518E-05	99.999%	99.999%
Fluoranthene	1549.9	11.34	6.62E-06	1.160E-03	-1.153E-03	100%	100%
Pyrene	1034.7	7.57	5.30E-06	7.700E-04	-7.647E-04	100%	100%
Benzo(a)anthracene	284.7	2.08	5.30E-06		5.299E-06	100%	100%
Chrysene	303.4	2.22	5.30E-06	1.500E-04	-1.447E-04	100%	100%
Benzo(b)fluoranthene	157.8	1.15	5.30E-06		5.299E-06	100%	100%
Benzo(k)fluoranthene	157.8	1.15	5.30E-06		5.299E-06	100%	100%
Benzo(a)pyrene	137.9	1.01	5.30E-06		5.299E-06	99.999%	99.999%
Dibenzo(a,h)anthracene	3.8	0.03	5.30E-06		5.299E-06	99.982%	99.982%
Benzo(g,h,i)perylene	29.1	0.21	5.30E-06		5.299E-06	99.997%	99.997%
Indeno(1,2,3-c,d)pyrene	36.2	0.26	5.30E-06		5.299E-06	99.998%	99.998%
Total PAH	9160.7	67.03	8.552E-04	5.150E-03	-4.295E-03	100%	99.999%
Chlorophenols							
Pentachlorophenol	265.9	1.95	2.65E-05		2.650E-05	99.999%	99.999%
Total chlorophenols	265.9	1.95	8.80E-05		8.802E-05	99.995%	99.995%
Other							
Hydrogen Chloride (HCl)	1089.68	7.97	3.82		3.820E+00	52.070%	52.070%
Sulfur dioxide (SO ₂)	2800	20.49	5.07		5.070E+00	75.256%	75.256%

End-of-Life Management of Treated Wood

Table Notes:

High fire scenario: HCl in fuel determined as Cl times 1.028: Cl=520

High fire scenario: SO₂ in fuel determined as S times 2: S=0.24%

Low fire scenario: HCl in fuel determined as Cl times 1.028: Cl=1,060

Low fire scenario: SO₂ in fuel determined as S times 2: S=0.14%

Wood fuel consisted of a mix of approximately 50% each of penta treated and creosote treated wood

Creosote content (approx)	1.52%	
Assumed solid wood density	38.47 lb/cf	
Creosote content (approx)	0.59 lb/cf	
Penta content (approx)	0.04%	
Assumed solid wood density	32.67 lb/cf	
Penta content (approx)	0.014 lb/cf	
Moisture content	37%	
Heat value	6190 BTU/lb	low fire test
	7150 BTU/lb	high fire test

APPENDIX 6 METALS EMISSION EVALUATION

Evaluation of Metals Emissions from Preserved and C&D Wood Combustion

Data below from Holzman and Atkins, 1995

Emissions from Combustion of Treated Wood Fuel and Tires in Industrial Boilers

From Table 1 of Holzman and Atkins 1995 (selected columns)								
Fuel Data	Units	Wood Chips	Bark	Yard Waste	Forest Residual	Creosote Treated wood	Penta treated wood	C/D Waste Wood
As received:								
Heat value	BTU/lb	4019	4806	2472	4169	6003	6738	6997
Moisture	(%)	53%	40%	42%	43%	27%	26%	16%
Dry Basis:								
Heat value	BTU/lb	8593	8011	4233	7347	8183	9057	8357
Ash	(%)	1.39%	2.65%	29.05%	4.79%	5.14%	1.10%	5.98%
Sulfur	(%)	0.18%	0.15%	1.00%	0.83%	0.40%	0.56%	0.81%
Chlorine	(%)	ND*	ND	0.23%	0.17%	0.02%	0.54%	0.08%
Table 2 - Elemental Metals								
Arsenic	(ppm)	ND	ND	0.01	3.61	1.97	ND	16.31
Chromium	(ppm)	1	0.5	0.12	4.77	4.21	ND	26.59
Lead	(ppm)	17.5	ND	11.14	14.14	64.13	ND	130.90
Copper	(ppm)	6.44	1.9	ND	ND	7.65	ND	33.53
* ND = No data								
Table 3 - Metals in ash (combined)								
Arsenic	(ppm)	39.1	ND	ND	ND	35.6	ND	632.4
Chromium	(ppm)	104.4	ND	ND	ND	227.6	ND	1661.0
Lead	(ppm)	424.6	ND	ND	ND	3598.0	ND	3726.6
Copper	(ppm)	436.9	ND	ND	ND	1047.3	ND	1024.6
Calculating from above								
Fraction of fuel in ash (ppm in ash x ash %)/ppm in fuel								
Arsenic	(%)					93%		232%
Chromium	(%)	145%				278%		374%
Lead	(%)	34%				288%		170%
Copper	(%)	94%				704%		183%

End-of-Life Management of Treated Wood

Emission data are used to calculate emission rates and then compare to metals in fuel to show fractions of input in ash and in emissions. Last, the emission fraction is shown as DRE.

Emissions Data	Units	From Table 4 of Holzman and Atkins 1995		From Table 4 of Holzman and Atkins 1995		Table 6 of Holzman and Atkins 1995 C/D Waste	
		Site A Clean Wood	Site B Clean Wood	Site A 25-50% Ties	Site B 20% Ties	Pac Oro Power	Site E
Heat input	MMBTU/hr	339	711	339	681	360	251
Arsenic	lb/MMBTU	1.44E-07	1.64E-05	7.97E-07	3.07E-05	5.27E-07	ND
Chromium		6.37E-07	3.36E-05	2.87E-06	4.09E-05	3.93E-06	3.00E-08
Lead		1.59E-05	9.84E-06	1.12E-05	2.20E-05	6.18E-06	1.88E-05
Copper		1.59E-05	ND	3.51E-06	ND	ND	5.00E-06
Calculating from above							
Treated or C/D wood	(%)	0%	0%	38%	20%	100%	100%
Treated wood fuel	lb/hr	41,427	86,887	15,535	16,644	43,078	30,035
Percent of input fuel emitted							
Arsenic	(%)	0.060%	6.812%	0.883%	63.761%	0.027%	ND
Chromium	(%)	0.124%	6.531%	1.488%	39.749%	0.124%	0.001%
Lead	(%)	0.203%	0.126%	0.381%	1.404%	0.039%	0.120%
Copper	(%)	1.701%	ND	1.001%	ND	ND	0.125%
Increase (treated - clean) as percent of fuel input							
Arsenic	(%)			7.23E-09	2.97E-07		
Chromium	(%)			1.16E-08	7.09E-08		
Lead	(%)			-1.60E-09	7.76E-09		
Copper	(%)			-3.53E-08	ND		
Apparent removal efficiency							
Arsenic	(%)			100.0%	100.0%	99.973%	ND
Chromium	(%)			100.0%	100.0%	99.876%	99.999%
Lead	(%)			100.0%	100.0%	99.961%	99.880%
Copper	(%)			100.0%	ND	ND	99.875%

End-of-Life Management of Treated Wood

Emission data are used to calculate emission rates and then compare to metals in fuel to show fractions of input in ash and in emissions. Last, the emission fraction is shown as DRE.

Emissions Data	Units	From Table 4 of Holzman and Atkins 1995		From Table 4 of Holzman and Atkins 1995		Table 6 of Holzman and Atkins 1995 C/D Waste	
		Site A Clean Wood	Site B Clean Wood	Site A 25-50% Ties	Site B 20% Ties	Pac Oro Power	Site E
Heat input	MMBTU/hr	339	711	339	681	360	251
Arsenic	lb/MMBTU	1.44E-07	1.64E-05	7.97E-07	3.07E-05	5.27E-07	ND
Chromium		6.37E-07	3.36E-05	2.87E-06	4.09E-05	3.93E-06	3.00E-08
Lead		1.59E-05	9.84E-06	1.12E-05	2.20E-05	6.18E-06	1.88E-05
Copper		1.59E-05	ND	3.51E-06	ND	ND	5.00E-06
Calculating from above							
Treated or C/D wood	(%)	0%	0%	38%	20%	100%	100%
Treated wood fuel	lb/hr	41,427	86,887	15,535	16,644	43,078	30,035
Percent of input fuel emitted							
Arsenic	(%)	0.060%	6.812%	0.883%	63.761%	0.027%	ND
Chromium	(%)	0.124%	6.531%	1.488%	39.749%	0.124%	0.001%
Lead	(%)	0.203%	0.126%	0.381%	1.404%	0.039%	0.120%
Copper	(%)	1.701%	ND	1.001%	ND	ND	0.125%
Increase (treated - clean) as percent of fuel input							
Arsenic	(%)			7.23E-09	2.97E-07		
Chromium	(%)			1.16E-08	7.09E-08		
Lead	(%)			-1.60E-09	7.76E-09		
Copper	(%)			-3.53E-08	ND		
Apparent removal efficiency							
Arsenic	(%)			100.0%	100.0%	99.973%	ND
Chromium	(%)			100.0%	100.0%	99.876%	99.999%
Lead	(%)			100.0%	100.0%	99.961%	99.880%
Copper	(%)			100.0%	ND	ND	99.875%

End-of-Life Management of Treated Wood

APPENDIX 7 PRESERVED WOOD TO ENERGY FACILITIES

North American Recyclers and Combustors of Used Treated Wood

Last Revised March 22, 2010

Company & Contact	Contact Info.	Location	TW Accepted	Other Information
Aboriginal Cogeneration Corp.	Kim Sigurdson 204-283-1484 OriginalAboriginal@shaw.ca	Canada	Creosote	Contract with CP. Not yet operational. Uses gasification process. (Investigating other preservatives.)
American Ref-Fuel Company of Niagara	Kevin Oneil 716-278-8548	Niagara Falls, NY	Pentachlorophenol	
Enerkem www.enerkem.com	Dino Mili 514-875-0284 ext 232 dmili@enerkem.com	Westbury, Quebec and Edmonton, Alberta, Canada	All used treated wood Municipal waste	Start-up in late 2008. Gasification to produce ethanol. Planning eventual expansion to other Canadian and U.S. locations.
Enerkem Corporation (USA) www.enerkem.com	Three Rivers Solid Waste Mgmt. Auth., Pontotoc, MS or Dino Mili 514-875-0284 ext 232 dmili@enerkem.com	Pontotoc, MS	Municipal waste	Pontotoc under construction in 2010 with startup in 2012-13.
Evergreen Packaging	Kelly Bryant, Environmental Group Leader, 870-541-5892 Kelly.Bryant@everpack.com	5201 Fairfield Road, Pine Bluff, AR 71601	Railroad Ties	From EPA Combustion Survey Database
Heritage-WTI, Inc. Incinerator www.heritage-wti.com	John Avdellas VP of Sales & Marketing 330-386-2173 T, 330-386-2167 F javdellas@heritage-wti.com	East Liverpool, OH	All used treated wood	Size restriction of 2' x 2' x 6" for material received in bulk (roll-offs or end dumps).
Holcium (US) Inc. - Hagerstown Plant	Michelle Ferguson, Manager, Corporate Environmental 803-496-2714 michelle.ferugson@holcim.com	1260 Security Road, Hagerstown, MD 21742	Treated Wood	From EPA Combustion Survey Database
Indianapolis Resource Recovery Facility	Bernie Heile 765-483-1505	Indianapolis, IN	Pentachlorophenol	
International Paper Louisiana Mill	Steve Wade 318-556-1549	Bastrop, LA	Pentachlorophenol	
International Paper Texarkana Mill	Doug Wadley, Manager of Environmental Performance 903 796-1638 doug.wadley@ipaper.com	9978 FM 3129, Queen City, TX, 75572	Rail Derived Fuel Chips	From EPA Combustion Survey Database
Koppers Inc. Susquehanna Plant www.koppers.com	Paul Beswick, 570-547-1651 BeswickPC@koppers.com	P.O. Box 189 Montgomery, PA 17752	Creosote	Cogeneration plant fueled primarily by railroad ties.
Lancaster County Solid Waste Management Authority Resource Recovery Facility www.lcswma.org	Kevin Weaver P 717-397-9968, F 717-397-9973 kweaver@lcswma.org	Lancaster, PA	All used treated wood	Burn all types of treated wood with municipal waste in incinerator. Limited to Lancaster County sources.

End-of-Life Management of Treated Wood

Company & Contact	Contact Info.	Location	TW Accepted	Other Information
Lehigh Cement Company www.lehighcement.com	Mark R. Stillwagon Purchasing Manager - North Region Lehigh Hanson, Inc. O 610-366-4761 mstillwagon@lehighcement.com	Blandon, PA Mitchell, IN. Other possible locations	Dry Treated poles Dry Rail Ties Dry Saw Dust	Program currently is experimental. All material ground to size of 3/4" or less. Supply MUST be consistent or it will not be considered. Any other dry, high BTU product with volatiles not above State or National permitted levels.
Lehigh Cement Company, Evansville Plant	Charles Bortz, Environmental Coordinator 484-248-1391 cbortz@lehighcement.com	537 Evansville Road, Fleetwood, PA 19522	Treated Wood	From EPA Combustion Survey Database
National Salvage & Service Corp.	Jason Fagans 812-339-9000 jason.fagans@nssx.biz	Selma, AL	Creosote	Processes used ties into fuel for sale.
Northern Sun – ADM	Richard Irish, Plant Manager 701-437-3000 Richard_Irish@admworld.com	5525 136th Ave. SE, Enderlin, ND, 58027	RR Ties	From EPA Combustion Survey Database
NSPW Bay Front Generating Plant	David Fulweber, Plant Manager 715-682-7200 david.fulweber@xcelenergy.com	122 N. 14th Avenue West, Ashland, WI, 54806	Treated Wood	From EPA Combustion Survey Database
RTI Railroad Services, Inc.	Charles Jacob 801-7566044 cjacob@rtirailroad.com	American Fork, UT	Creosote	As service contractor to railroads, can handle, grind, and sell wood as fuel.
SP Newsprint Co., LLC - Newberg Mill	Stan Miller, Environmental Engineer 503-537-6278 stan.miller@spnewsprint.com	1301 Wyooski Street, Newberg, OR 97132	Creosote	From EPA Combustion Survey Database
Springfield Resource Recovery	Meg Morris 518-434-1227	Albany, NY	Pentachlorophenol	
Staceyville	Brenn Bernhardt 207-365-4251 x223	Staceyville, ME	Pentachlorophenol	
Stone Container Florence Mill	Timothy Paasch 843-269-0107	Florence, SC	Pentachlorophenol	
Tangent Rail Energy www.tangentrail.com	Jyll Campbell 913-310-9888 ext. 237 jcampbell@tangentrail.com	1. Goldsboro, NC 2. Mount Meigs, AL 3. Duluth, MN	Creosote	Primarily ties, grind to produce fuel for sale to permitted boilers
Viking Energy of McBain	Thomas Vine, Plant Manager 231-825-2772 x19 thomas.vine@suezenergyna.com	6751 W. Gerwoude DR., McBain, MI, 49657	Treated Wood	From EPA Combustion Survey Database
Viking Energy of Lincoln	Neil Taratuta, Plant Manager 989-736-6618 neil.taratuta@dgsuezna.com	509 W. State St., Lincoln, MI, 48742	Creosote	From EPA Combustion Survey Database

End-of-Life Management of Treated Wood

Company & Contact	Contact Info.	Location	TW Accepted	Other Information
Waterway Recycling, LLC www.waterwaymarineterminal.com	Gene Hand, Manager O 757-333-3427, F 757-333-3987 C 757-478-7773 ghand@precononline.com	Chesapeake, VA	Creosote	Port location. Accept material by truck or barge. Grind and sell for fuel to permitted boiler.
Weyerhaeuser Company - East Kentucky Plant	D.J. McKenney, Plant Engineer 606-436-8964 david.mckenney@weyerhaeuser.com	610 Truss Joist Lane, Chavies, KY, 41727	Treated Wood	From EPA Combustion Survey Database
Weyerhaeuser Longview WA	Jeff Inman 360-414-3340	Longview, WA	Pentachlorophenol	
Wheelabrator Shasta www.wheelabratortechnologies.com	George Woodward, Plant Manager 530-339-7600 gwoodward@wm.com	Anderson, CA	Creosote	Electric generation. Ties from U.P. & others.
Wheelabrator Environmental Systems, Inc.	Phil Tuohy 863-665-2255 x112	Auburndale, FL	Pentachlorophenol	

APPENDIX 8 AQUAETER QUALIFICATIONS

This End-of-Life Management of Preserved Wood paper has been prepared by AquaAeTer, Inc. Since our establishment in 1992, **AquaAeTer** worked with the wood preserving industry. **AquaAeTer** is a multi-disciplinary environmental consulting firm providing environmental sciences and engineering services. We are active members of the Western Wood Preservers Institute (WWPI) and the Treated Wood Council (TWC), and the predecessor organization American Wood Preservers Institute (AWPI). A significant portion of our work has been for wood treaters, including oil-borne and water-borne treaters.

Currently, AquaAeTer is assisting TWC with the preparation of Life Cycle Assessments (LCAs) of six preserved wood products. The goal of the LCAs is to identify the environmental impacts attributable to preserved wood products, identify opportunities to lessen impacts, complete LCAs for alternative products, and make comparisons of the product impacts. The scope of the product covers the cradle-to-grave life cycle of the preserved wood products and their alternatives.

AquaAeTer's better-known accomplishment was the development of the air emission model used for the calculating overall facility emissions used for permitting and SARA form R reporting purposes. The model was widely accepted by USEPA and as the standard for performing these calculations.

We have gained valuable expertise during several litigation support projects related to air emissions from wood treating facilities. These projects included the design and implementation of complex ambient air monitoring and soil sampling programs. The scientific data in those studies were used in conjunction with expert testimony in high-profile civil lawsuits.

AquaAeTer's work in other industries includes paper and wood products manufacturers, waste management companies and municipal landfills, steel manufacturers, chemical companies and plastics. This industry work includes projects related to the life cycle of alternative products; monitoring greenhouse gas emissions; landfill monitoring and corrective action; air and water emissions; TRI reporting; solid and hazardous waste disposal; and methane gas oxidation research.