Disposal of Treated Wood

Jeffrey J. Morrell
Oregon State University, Corvallis, Oregon 97331

ABSTRACT

Preservative treatment has markedly extended the useful lives of a variety of wood products, but eventually these materials must be disposed. There is a continuing dilemma about how to manage materials that, while treated with toxic chemicals, have largely had little or no impact while in use. This presentation reviews the disposal options currently available and their limitations using utility poles as the primary examples.

Introduction

Preservative treatment has many beneficial aspects, but one of its most important is that it prolongs the useful life of wood products exposed in extreme environments, markedly reducing the need to harvest our forests while improving the reliability and safety of a variety of structures. While preservative treatments can extend the useful life of a wood product by 20 to 40 times that of untreated wood, eventually, even this durable material must be removed from service. The same chemicals that protect wood against degradation can have negative impacts at the end of the product's useful life.

Disposal of treated wood was once of minimal concern to users and society as a whole, but changing public perceptions concerning the risk of chemical usage and, ultimately, the disposal of products in which they are contained have resulted in a re-evaluation of disposal practices. The dilemma facing users of treated wood is how to convey the message that products that have served benignly in a variety of environments for decades do not instantly become hazardous when they are removed. Challenging this perception will require a combination of education and development of technical information on the various methods of disposal and the relative risks they pose. Compounding the problem is the fact that nearly all preservatives are inherently toxic at some level to a variety of non-target organisms. As a result, developing solutions for dealing with treated wood wastes will require a combination of approaches that recognize and perhaps even take advantage of these attributes.

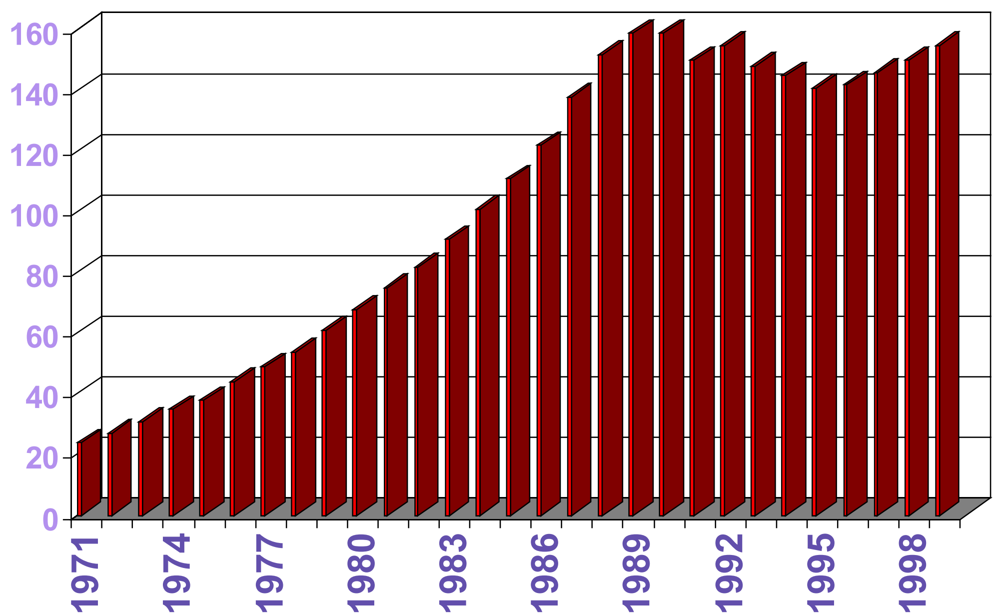

Figure 1. Production of treated wood between 1950 and 1990 (AWPA, 19).

In addition to changing perceptions about chemicals, a number of other factors will influence treated wood disposal. The production of treated wood increased steadily beginning in the 1970s and although growth has slowed somewhat, demand continues to increase (Figure 1). In the 1950s, most treated wood was used for industrial purposes such as poles, railroad ties and piling. These materials were largely handled by personnel who were familiar with their properties, albeit with an environmental ethic consistent with the times. Treated products were most often discarded because they experienced either decay or mechanical wear and the primary chemical used at that time (creosote) was eventually biodegradable.

The growth in treated wood production has primarily occurred on the dimension lumber side where chromated copper arsenate (CCA) treated decks have become a common housing feature. The users of these products generally have a poor understanding of the properties. In addition, these products are often removed from service while they are still biologically sound because of unsightly weathering of the wood surface. The chemicals in these products do not biodegrade and large quantities remain in the wood that is disposed. Finally, the user has little knowledge of what constitutes proper disposal. One major concern with this material is the knowledge that the growth in treated wood production seen in the 1970s will be followed by a similar growth in disposal as these materials reach the end of their useful lives. There is some debate about when this will occur. Recent studies of consumer deck perceptions (Smith, XXXX) suggesting average service lives between 10 and 15 years would mean that this disposal phenomena is already underway.

A second factor confounding this issue is the overall disposal process. For decades landfilling was the most common method for disposing of bulky materials such as wood. The process, however, was crude, with a high potential for surface and groundwater contamination. Federal regulatory changes led to the installation of landfill facilities with liners and leachate collection systems. These changes also sharply reduced the number of available landfills in some regions and encouraged the development of alternative disposal options, including cogeneration, construction/demolition facilities and stronger recycling programs to extend landfill life. These efforts varied widely among the states. Many western states continued to rely on traditional land-disposal. Some states, such as Florida saw sharp reductions in available landfill space and aggressively develop alternative strategies.

It is some of these alternative strategies that have caused the greatest concern. Paramount among these has been burning of treated wood collected from C and D facilities to produce electricity. This practice initiated the series of events that led to the planned withdrawal of CCA for treatment of wood used in nonresidential applications. While this process will have been completed by the end of 2003, billions of board feet of wood treated with this and other chemicals remain in service. The question is can we devise a national strategy for dealing with this resource that takes into account public concerns. While ensuring a reasonable ability to safely dispose of these materials. In this report, we will review the options available for dealing with treated wood in the disposal stream.

One challenge facing those seeking to find options for disposal is the dispersed and diverse nature of the treated wood resource. Treated wood comprises a variety of commodities including poles, piles, ties, timbers. lumber, and plywood. These materials are treated with any number of chemicals that include organic and metallic systems. While some of these materials are easily distinguished, weathering can make if almost impossible to visually sort some treatments. Finally, treated wood is produced in relatively few locations (<600), but it is used across the landscape. This dispersed resource is costly to collect, sort and ship to sites where it can be effectively recycled.

We will examine disposal strategies using three commodities, railroad ties, utility poles, and CCA treated decking.

RAILROAD TIES

Railroad ties formed the backbone of the original treating industry in North America. Railroads used enormous quantities of wood to support the rails with up to 3500 ties per mile of track. The expansion of the railroads in the late 1800s placed enormous pressure on forest resources and fears about depletion of domestic timber supplies for ties was one of the underlying reasons for the establishment of our national forest system. The development of the preservative treatment industry markedly improved wood service life and effectively ended the concerns about running out of wood.

Most ties are treated with creosote or creosote/petroleum mixtures, although some are treated with pentachlorophenol in oil. A well-treated tie is usually removed because it has failed mechanically either through an inability to hold spikes or through excessive wear beneath the plate. In many cases, a majority of the tie remains serviceable and the relatively sound wood has found a ready secondary market for use in retaining walls or as parking bumpers. Concerns have been raised about the potential for migration from these secondary uses, however there is little data showing any significant potential effects. Given their prior usage, it is likely that any large chemical losses occurred in track, markedly reducing the risk of further substantial migration. In addition, creosote components are largely biodegradable in soil.

Creosote-treated ties that are no longer serviceable for walls have found ready outlets for cogeneration facilities since the materials have excellent fuel value. As a result, disposal of treated ties is relatively simple process.

UTILITY POLES

Wood utility poles remain the mainstay of the North American distribution and lower voltage transmission systems. The combination of low initial cost, ease of handling, high reliability, and exceptional service life have combined to make wood an obvious choice for a variety of applications.

Although treated wood poles will provide exceptional service, eventually, the pole condition declines to the point where it must be replaced. For decades, utilities disposed of used poles in a variety of simple ways including give-aways to adjacent landowners, donations to civic groups and when all else failed, leaving the cutup pole by the side of the road where it mysteriously disappeared. Increasing public sensitivity concerning the use of chemically treated products has heightened awareness of pole disposal among both utility engineers, their environmental specialists and the general public. Many utilities are re-evaluating their disposal options, but there is little information on many possible disposal technologies, nor do all strategies appear to be suited for all treatments used across the U.S.

Magnitude of the Issue

There are over 160 million utility poles in service in North American with a majority of these poles being in the range of 30 to 40 feet long. Creosote poles represent perhaps 20% of the population, penta 50% and inorganic arsenicals the remainder. While utilities estimate pole service life at 30 to 40 years, poles appear to last far longer in most areas, ranging from 60 to 80 years. Combinations of better inspection, aggressive remedial treatments and reinforcing could further extend these figures. In total, it would appear that approximately 1 million poles are purchased each year, but this figure includes new construction. If we assume that 20% of this production is new construction, then utilities must deal with disposal of 800,000 poles per year. A 1998 survey in the western U.S. suggested that a majority of utilities still gave away nearly all their poles and had little problem taking the remainder to Municipal Solid Waste (MSW) facilities (Table 1). These utilities reported that disposal was a concern, but noted that they spent relatively little on disposal (<$50,000/year). This suggests that the reality of pole disposal is different from its perception. Utilities in more urban settings that lack agricultural outlets for poles face the greatest challenge, but there are also a variety of possible outlets for these materials.

Factors Affecting Disposal

Pole Condition: While we typically think of disposed poles as badly damaged, many poles are removed for reasons other than degradation including road widening and line upgrades. These poles are probably reusable, but would require reinspection. Many utilities hesitate to reuse poles, although there is tremendous evidence that it can save money without compromising the system. The remainder of removal poles have some type of defect. For example, decay at ground in, shelling or a weathered top. Even these poles are not completely unusable, although some processing would be required to recover the reusable portion of the pole and the creation of some waste that required disposal would be inevitable. Although some poles, such as those impacted by automobiles, may be largely destroyed, it is important to consider that a majority of poles retain considerable usable material when removed from service. In addition, the material requirements for poles such as knot limitations, grain patterns and the near absence of spiral grain make this wood a potentially valuable resource for other applications (ANSI, 1992).

<u>*Wood Species and Initial Treatment Chemicals*</u>: Wood species can influence potential reuse as a result of initial treatment characteristics. For example, western redcedar has a naturally durable heartwood that resists preservative treatment. Most of the wood in the pole is free of chemicals, although the outer sapwood is often weathered and has lower strength.

Table 1. Summary of responses to pole disposal practices surveys administered in 1988, 1997, 1999 (Hess, 1988; Morrell and James, 1997, Morrell, 1999; Love et al., 2000).[a]

Topic	1988	1997	1999	2000
# of poles	-	8.2 million	9.2 million	1.9 million
# poles disposed	-	44,480	44,180	15,500
Treatment Chemicals				
Penta	92 %	95 %	92 %	64 %
Creosote	13 %	23 %	33 %	33 %
Arsenicals	6 %	5 %	22 %	<1 %
Cu-Naphthenate	12%	32 %	18 %	1 %
Disposal Method				
Give away	85 %	77 %	88 %	90 %
MSW Facility	40 %	45 %	55 %	60 %
Hazardous	5 %	13 %	14 %	20 %
Incinerate	-	5 %	4 %	-
Sell	-	19 %	10 %	-
Resaw	-	3 %	2 %	-

Disposal Costs Per Year				
< $50,000	-	83 %	96 %	-
$50,000-100,000	-	2 %	4 %	-
$100,000 to 250,000	-	11 %	-	-
>$250,000	-	4 %	-	-
Sample size	65	62	51	10
[a] Values in some columns add to more than 100 % because of rounding.				

Douglas-fir also has a high percentage of difficult to treat heartwood; but this wood is only moderately durable. There may also be a substantial internal decay near the original ground in as well as near any field drilled holes. These defects will reduce recovery and increase the amount of waste generated. Southern pine has a high percentage of easily treated sapwood, but some treatments are prone to surface decay. Surface decay may make the below ground portion of the pole unusable. In addition, a majority of the wood will have preservative treatment. The presence of treatment largely relegates this material to exterior applications where there is a risk of decay; however, some retreatment will be necessary since the preservative distribution will likely differ from that of freshly treated lumber.

Treatment chemicals and the degree to which they penetrate the wood can also influence disposal. This problem is minor with cedar, but could be a major concern with southern pine. These concerns may limit applications to exterior locations where odors and residual chemicals are of less concern. The presence of some preservatives in this material may also preclude some disposal options such as combustion for cogeneration. For example, metal preservatives should not be burned nor should large quantities of pentachlorophenol treated wood be used for cogeneration.

__Distance from Disposal Site__: Wood is a bulky material with relatively low value. As a result, transportation costs for moving poles from the line to a disposal site can be significant, particularly given the low value of a now unusable pole. For example, Love and Morrell (2001) examined trucking costs for poles in the Pacific Northwest and found that transportation of cedar poles for resawing into lumber was practical within a range of 200 miles, although the benefit was greatest with increasing pole size (where recovery would presumably be greater)(Table 2). Transportation costs for other disposal options with less potential for value recovery, such as cogeneration for energy recovery, would be further constrained.

Table 2. Number of poles per truckload and costs to transport Douglas-fir and western redcedar poles 70 or 200 miles

Pole Class/Length	Number of poles/truckload		Transport Cost/Pole			
			Douglas-fir		W. redcedar	
	Douglas-fir	W. redcedar	70 mi	200 mi	70 mi	200 mi
4- 40 feet	40	59	$6.50	$13.33	$4.41	$9.03
1-70 feet	10	14	$26.00	$53.30	$18.57	38.07

Table 3. Relative costs to dispose of distribution and transmission poles in municipal solid waste facilities charging two tipping fees.

Wood Species	Class/Height	Disposal Costs/Pole ($)

		Lowest Cost	Highest Cost
Douglas-fir	4/40 feet	$5.41	$20.00
	1/70 feet	$19.60	$65.38
Western redcedar	4/40 feet	$4.70	$15.68
	1/70 feet	$17.73	$59.09

Lumber and Timber

Dimension lumber treated with chromated copper arsenate comprises one of the two largest contributors to the treated wood disposal issue. Unlikely other treated wood products which are mostly used for industrial applications, CCA treated lumber tends to be widely dispersed in residential applications. The users of these products despite marginal industrial education efforts, are largely ignorant of the properties of these materials. As a result, most users inherently know that treated wood is more durable and that it contains chemicals, but they know little about its properties or routes for proper disposal. In addition, much of this material is used in decks and other horizontal exposures where it is highly prone to Ultraviolet (UV) light degradation, cupping, warping, and twisting that change the appearance. The poor physical performance of CCA-treated decking is a major contributor to the rise in levels of these materials entering the waste stream and clearly illustrates why changes in practices to produce more UV and water resistant decking wood should be a major goal of the treating industry.

At present, however, users of CCA-treated wood are faced with a dilemma about how to dispose of this material at the end of its useful life, when it may be physically weakened, but free of biological attack and retain nearly all of the original preservative. While the EPA would recommend reuse of these materials, there are several challenges to this approach. First, the material is disposed in many locations among numerous users. The wood has often been cut to varying lengths and may still contain nails or screws. Surface appearance is a major limit to reuse in similar applications and resawing of dimension lumber to remove the weathered surfaces would markedly reduce the dimensions, producing boards with dubious structural value.

Finally, while the wood is treated, current standards allow retentions for soil and above ground applications and it is impossible to determine which treatment level is present without chemical analysis. As a result, traditional reuse and remanufacturing such as that observed with poles and ties is largely not feasible for these materials.

The looming volumes of CCA treated wood that will enter the waste stream over the next 30 years, place added urgency on the need to identify suitable methods for dealing with these materials in an environmentally responsible fashion. Landfilling, while simple, would consume large volumes of precious capacity while wasting a potential reusable resource. The challenge over the next decade will be to identify economical alternatives and implement strategies for using this resource.

Disposal Options

Give-Aways: Utilities have given away poles for decades, but there is increasing concern about the potential for misuse by the recipients of these materials. Many utilities now require that recipients of used poles sign a release form acknowledging that they have read an information sheet about the chemicals in the wood. Some utilities file these in the event issues arise, but it appears that most utilities do not track these records. Giving away treated lumber is inherently problematic. The wood is often damaged and, given the small dimension, easy to cut up and burn.

Give aways have the advantage of low cost and simplicity, but they also mean that the utility has little control over the ultimate disposal of the treated wood. While most uses have minimal risk, the primary concerns would be that the recipient would either burn the wood, use large numbers near surface waters, or in the cases of oilborne chemicals, use the wood in an enclosed, inhabited space without some form of surface sealing. Educating potential users probably represents the best approach for limiting risk on this issue, but requires continuous vigilance to be certain that the education continues as clients change.

Land Filling: Most landfills that are lined and have leachate management systems will accept treated wood wastes, although the costs can vary. Some communities have also established wood waste recycling programs to divert this material from landfilling, but care must be taken to ensure that treated materials do not enter the recycling stream where the wood is normally either composted or combusted (Alderman and Smith, 2000; Morrell and Lopath, 2000; Solo-Gabriel et al., 2000).

Landfilling can be a relatively low cost option in some regions. Pole disposal in the Pacific Northwest costs as little as $5.41 for a class 4-40 foot long Douglas-fir pole (Love and Morrell. 2001) (Table 3). As a result, landfilling should be the last alternative for disposal. The ability to dispose of treated wood in a landfill is driven by the ability of the material to pass a Toxicity Characteristic Leaching Profile (TCLP) test. TCLP involves grinding and extracting the wood, then analyzing the extracts. At present, all treated wood is disposable in municipal solid waste facilities, although these facilities retain the discretion to reject these materials. Virtually all creosote or pentachlorophenol treated wood will pass TCLP, although landfill operators may ask for specific tests from individual users (Goodrich-Mahoney, 1992; Malecki, 1992; Murarka et al., 1996; Vassou et al., 1998). Chromated copper arsenate and ammoniacal copper zinc arsenate are exempt from TCLP. Landfilling all wood removed from service would produce tremendous volumes of material that would quickly overwhelm our existing landfill capacity.

Some utilities take landfilling concerns as a great responsibility and dispose of their poles in secure hazardous waste facilities. There is no evidence to suggest that this approach is necessary and it adds obvious costs to the disposal process.

Combustion for Cogeneration: One disadvantage of both give aways and landfilling is that the wood remains largely intact and a potential liability for the former owner. Combustion offers the potential for completely eliminating the wood, while simultaneously offering the ability to create electricity and steam. Combustion has long been used for ????????????? of creosoted railroad ties, poles and timbers (Conlon, 1992; Kempton, 1992; Webb, 1992). Combustion of creosote at high temperatures is relatively simple and there are a number of facilities licensed for this purpose across the U.S. Combustion of pentachlorophenol (penta) or the inorganic arsenicals poses a much greater challenge. Combustion of penta treated wood can produce dioxins and furans, and most facilities that burn wood try to avoid exceeding emission limits usually by limiting the overall percentage of penta treated wood that is burned (Karakash and Lipinski, 1998; Smith, 1992).

Table 4. Estimated disposal costs for the treated component of Douglas-fir and western redcedar distribution and transmission poles.

Wood Species	Pole Class/Length	Treated Zone (in)	Treated Wood Weight (lbs.)[a]	Disposal Costs ($/Pole)[b]
Douglas-fir	4-40 feet	1.0	241 lbs	$ 2.17
		2.0	419 lbs	$ 3.77
	1-70 feet	1.0	622 lbs	$ 5.60
		2.0	1,139 lbs	$10.25
Western redcedar	4-40 feet	0.5	106 lbs	$ 0.95
		1.0	199 lbs	$ 1.79
	1-70 feet	0.5	274 lbs	$ 2.47
		1.0	526 lbs	$ 4.73

[a] Assumes that treated densities for Douglas-fir and western redcedar are 36 and 28 pounds per cubic foot, respectively.

[b] Assumes a disposal cost of $18.00 per ton in a municipal solid waste facility

Table 5. Relative volumes of treated wood in poles containing various amounts of preservative treated shell.

Wood Species	Pole Class/Length	Estimated Total Volume (ft^3)	Total Treated Wood Volume (ft^3)		
			0.5 in.	1.0 in.	2.0 in.
Douglas-fir	4/40 feet	16.69	-	6.70	11.64

	1/70 feet	60.54	-	17.28	31.65
W.redcedar	4/40 feet	18.67	3.78	7.11	-
	1/70 feet	70.34	9.77	18.78	-

Combustion of CCA and ACZA creates two risks. First, arsine gas can be produced, although this material can be trapped and removed from the stack gases. The resulting ash however will contain high metal levels that necessitate more expensive disposal options. The current furor over CCA was driven, in part, because of the discovery that substantial quantities of CCA treated wood entering Florida construction and demolition facilities was being burned to produce electricity. Tests of the resulting ash initiated a more detailed investigation of disposal practices (Solo-Gabriele et al., 1999). At present, combustion of inorganic arsenically treated wood is neither recommended nor practical on a large scale.

Since creosoted wood represents only 15 to 20% of the treated wood in service, it would appear that combustion is only a limited disposal option for treated wood.

Reuse: While some utilities will recycle poles that have been in service for only a short time, most see this practice as risky since it is sometimes difficult to accurately assess internal condition. In most cases, there is little risk of decay in the first few years, so reusing poles that have been in service for less than 5 to 10 years probably poses little risk. Where deterioration is a concern, the application of an external preservative paste or bandage or internal fumigant can limit the potential for decay and allow reuse. The potential for reusing older poles remains unknown. While typical internal inspection methods are relatively crude, it may be possible to combine some of these methods with emerging non-destructive evaluation (NDE) technologies to detect large internal defects and estimate residual strength. This would allow utilities to identify truly weak poles and only reuse those poles that still conform to their original design values.

Reuse of solid-sawn, treated wood would pose some different challenges primarily related to the fact that this wood often has been fabricated on site. As a result, the reuse must taken into account the present of bolt holes, notches and other features that may affect material properties. In addition, the wood is often weathered, checked and warped, making construction more challenging. Finally, the appearance of the wood will likely lead to concerns about material properties. Although surface defects are unlikely to markedly reduce strength, perceptions based upon appearance may make it difficult to find markets for these materials.

The development of consistent methods for assessing wood condition would allow utilities to reuse a higher percentage of poles, reducing both procurement and disposal costs. At present, however, total recycling of treated wood is probably not feasible.

Resawing: Pole stock could also be highly desirable for saw logs, provided there was some way to handle the treated wood component (Table 4, 5). For example, field trials with older cedar poles by the Bonneville Power Administration and USDA Forest Service indicated that recoveries from poles did not differ markedly from that found with sawlogs (Cahill and Parry, 2002). Poles are straight, have minimal taper and knots, and tend to be cut from slower growing trees. These attributes should produce a higher grade of lumber and there are several smaller commercial operations processing used cedar poles. Similar outcomes would be expected for large treated timbers.

Douglas-fir poses a slightly greater recovery challenge because of the slightly higher proportion of treatment and the tendency for the pole to contain some internal deterioration. Despite the slightly lower recoveries, preliminary tests indicate that resawing Douglas-fir poles is both feasible and economical.

Resawing southern pine poles and timbers is also relatively simple, but finding markets for the resulting products will be more difficult because a majority of the wood will be chemically treated (Roliadi et al., 2000b; King and Lewis, 2000). While it might be possible to sell this wood as treated, resawing will produce boards with varying degrees of preservative retention. At least one study has looked at recovery rates from southern pine poles, but their theoretical rates imply that much of the recovered wood was treated. This wood could be retreated, but it is unclear whether this material would have suitable markets since retreatment is likely to produce excessively high retentions and there would be questions about compatibility between oilborne treatments in some disposed wood and the waterborne preservatives that are currently used.

Two other problems with resawing poles are transportation to the saw and disposal of the treated wood. To date, resawing operations have often not paid for the wood they receive, although they may pay to transport it to the mill. Disposal of treated byproducts does not appear to be a problem in locations where these operations exist, but it does add a cost to the process. Metal fasteners (nails, bolts and other hardware) can also pose a problem, but these can be removed prior to sawing.

At present, resawing operations using treated wood appear to be localized entrepreneurial activities that primary process poles. They can play a role for some utilities that have adequate supplies of rejected poles in relatively contiguous areas, but it is unlikely that they are feasible for all utilities nor is it likely that there is an economic justification for construction of larger resaw facilities that could consolidate disposed poles from a number of utilities.

At present, resawing or otherwise reprocessing treated lumber remains problematic. Resawing of CCA-treated lumber is probably not feasible because nearly all of this material is already in dimensional configuration (2 to 3 inches thick). While it might be possible to plane the wood to remove the weathered wood, this process reduces the cross section and generates treated wood waste.

Reconstituted Wood Products: Engineered wood products composed of veneers, flakes, strands or other wood components represent an increasingly important segment of the wood products industry and it is relatively easy to see how treated wood might be reconstituted into such products (Cooper, 1993; Anonymous, 1990; Felton and DeGroot, 1996; Geimer, 1982; Huang and Cooper, 23000; Munson and Kamden, 1998; Roliadi et al., 2000a; Vick et sal., 1996). Wood breakdown would entail some of the same issues faced by resawing operations including metal contamination, decay, and preservative presence. The presence of some preservatives can have dramatic effects on the ability to bond individual wood components (Vick et al., 1996). In addition, particles and flakes are typically cut from relatively low density woods with less value. It is difficult to see how the species used for treated wood products in the U.S. could compete in this market without some type of subsidy. For example, many municipal recycling facilities charge a fee to take waste wood and then sell this material on the open market. Even with free wood and a user fee, most facilities require subsidies to operate.

A further issue would be the willingness of composite manufacturers to incorporate preservative treated wood at their facilities. Many manufacturers have a strong aversion to the use of preservatives, although some are now incorporating biocides such as boron in their furnish to produce durable panels for special markets. Given the dispersed nature of the disposed treated wood, it may be difficult to economically assemble sufficient quantities of material to support an individual facility.

Extraction/Detoxification: A number of efforts have been made to remove preservative from wood, either by chemical extraction or bioremediation. These efforts have primarily occurred in Europe where differing regulations regarding chemicals have encouraged the development of these processes.

Extraction using organic solvents is clearly possible for penta and creosote treated wood, but the costs of these procedures are extremely high and it is sometimes difficult to completely recover all solvent. Supercritical carbon dioxide extraction has been used experimentally for removing pentachlorophenol (Levien et al., 1994; Ruddick and Cui, 1995), but the equipment is costly and the process incomplete.

Bioremediation using bacteria or fungi has also shown promise for organic preservatives, but it is slow and incomplete (Lamar, 1995; Lamar and Dietrich, 1992; Messner and Bohmer, 1998; Portier and Kressbach, 1992). Bioremediation of metal treated wood is more difficult since the chemicals can not be broken down, but instead must be solubilized in the wood so that they can be removed in subsequent steps. A number of fungi have been shown to render the metals susceptible to subsequent leaching treatments and there is considerable interest in these technologies in Europe.

The primary drawbacks of both chemical and biological extraction are cost and the inability to completely eliminate preservative. The resulting process leaves a much reduced volume of preservative-contaminated residue of dubious value that will likely wind up in a MSW facility.

The Future

It is clear that all materials (not just treated wood) will face ever more stringent disposal requirements and this is clearly illustrated by more rigorous regulations to minimize packaging waste imposed in parts of Europe. Despite these concerns, most treated wood appears to be a desirable product for other applications. Utilities would be wise to develop educational materials to provide with their poles or restrict donations or sales to contractors, but disposal does not appear to be a major deciding factor for pole use. Disposal of treated dimension lumber poses a much greater challenge because of the overall lack of collection sites and technologies capable of handling the volumes that could be generated. In some regions, however, disposal will become an issue due to diminished landfill capacities and lack of recycling options. Fortunately, there appear to be a number of emerging solutions to these problems as we will see in the remainder of this meeting.

Literature Cited

Alderman, D.R., Jr. and R.L. Smith. 2000. Solid wood received and marketed by Virginia landfill facilities. Forest Products Journal 50(6):39-44.

American Wood Preservers' Association (AWPA). 1999. Annual Book of Standards. AWPA, Granbury, TX. 466 p.

American National Standards Institute (ANSI). 1992. Specification and dimensions for wood poles. ANSI 05.1-1992. ANSI, New York, NY. 26 p.

Anonymous. 1992. Salvaging utility poles: Turning poles into wood and paper products. Electrical World October:70-71.

BioCycle. 1997. Woody materials recycling: Recovering treated lumber. BioCycle 38(7):34-37.

Cahill, J. and D. Parry. 2002. Retired poles make good fencing products. In: Proceedings Northeast Utility Pole Conference, October 22-23, Binghamton, NY.

Conlon, P. 1992. Crosstie disposal problem or opportunity? Proceedings of the Treated Wood Life-Cycle Management Workshop, American Wood Preservers Institute, Vienna, Va. p.18-26.

Cooper, P.A. 1993. The potential for reuse of treated wood poles removed from service. *In:* Proc. 2nd Inter. Symp. on Wood Preservation. Doc. No. IRG/WP 93-50001. Inter. Res. Group on Wood Preservation, Stockholm Sweden. p. 251-264.

Electric Power Research Institute (EPRI). 1990. Pentachlorophenol (PCP)-treated wood poles and crossarms: Toxicity characteristic leaching procedures (TCLP) results. Prepared by the Environmental Management Services, Interim Report EPRI EN 7062, EPRI, Palo Alto, CA.

Felton, C.G. and R.C. DeGroot. 1996. The recycling potential of preservative-treated wood. Forest Prod. J. 46(7/8):37-46.

Geimer, R.L. 1982. Feasibility of producing reconstituted railroad ties on a commercial scale. Res. Pap. FPL-411. Madison, WI: USDA Forest Service, Forest Products Laboratory. 8 p.

Goodrich-Mahoney, J. 1992. TCLP test data on utility pole and crossarms treated with penta and creosote. In: Treated Wood Life-Cycle Management Workshop Proceedings, American Wood Preservers' Institute, Vienna, Virginia Pages 195-213.

Hess, R. 1988. Handling and disposal practices of Northwest utilities. In: Proceedings, Wood Pole Conference, October 20-21, Portland, Oregon. p. 26-27.

Huang, C. and P.A. Cooper. 2000. Cement-bonded particleboards using CCA-treated wood removed from service. Forest Prod. J. 50(6):49-56.

Karakash, J. and G. Lipinski. 1998. Disposal of pentachlorophenol-treated wood by combustion, report of recent compliance testing and project status. Proceedings Northeast Utility Pole Conference. Binghamton, New York. p. 60-62.

Kempton, C.C. 1992. Life cycle management of treated wood products: issues & answers. Proceedings of the Treated Wood Life-Cycle Management Workshop, American Wood Preservers Institute, Vienna, Va. pp. 54-105.

King, S.A. and D.K. Lewis. 2000. Solid wood products from used utility poles: an economic feasibility study. Forest Products Journal 50(11/12):69-78.

Labat, G. 1998. Alternative technologies for wood waste recycling. Document No. IRG/WP 98-50101, International Res. Group on Wood Preservation, Stockholm Sweden. p. 205-220.

Lamar, R.T. 1995. Use of wood-decay fungi for disposal of PCP-treated wood. *In:* Proc. 3rd Inter. Symp. on Wood Preservation. Doc. No. IRG/WP 95-50040. Inter. Res. Group on Wood Preservation IRG Secretariat, Stockholm Sweden. p. 441-449.

Lamar, R.T. and D.M. Dietrich. 1992. Use of lignin-degrading fungi in the disposal of pentachlorophenol-treated wood. J. of Industrial Microbiology 9:181-191.

Levien, K.L., J.J. Morrell, S. Kumar, and E. Sahle-Demessie. 1994. Process for removing chemical preservatives from wood using supercritical fluid extraction. U.S. Patent No. 5, 364, 475. Washington, DC.

Malecki, R.L. 1992. The utility perspective on treated wood life-cycle management. Proceedings of the Treated Wood Life-Cycle Management Workshop, Am. Wood Preservers Institute, Vienna, Va. p. 27-50.

Mankowski, M., E. Hansen, and J. Morrell. 2002. Wood pole purchasing, inspection and maintenance: a survey of utility practices. Forest Products Journal 52(11/12):43-50.

Messner, K. and S. Bohmer. 1998. Evaluation of fungal remediation of creosote treated wood. Paper IRG/WP 98-50101, International Res. Group on Wood Preservation, Stockholm Sweden.

Morrell, J.J. 1999. Pole disposal in the Pacific Northwest . In: Proceedings Utility Pole Structures Conference and Trade Show, Reno, NV, October 21-22. p. 53-59.

Morrell, J.J. and R. James.1997. Pole disposal in the Pacific Northwest . In: Proceedings Utility Pole Structures Conference and Trade Show, Reno, NV, November 6-7. p. 27-36.

Morrell, J.J. and S. Lopath. 2000. Treated wood waste in the recycling stream. Proceedings American Wood Preservers' Association 96:44-47.

Munson, J.M. and D. Kamden. 1998. Reconstituted particleboards from CCA-treated red pine utility poles. Forest Prod. J. 48(3):55-62

Murarka, I.P., R. Malecki, B. Taylor, B. Hensel, and J. Roewer. 1996. Release, migration, and degradation of pentachlorophenol around in-service utility poles. Proceedings American Wood Preservers' Association 92:180-187.

Portier, R.J. and J.N. Kressbach. 1992. Recovery of wood fiber from treated wood products by combined physical, chemical, and biological approaches. Proceedings of the Treated Wood Life-Cycle Management Workshop, Am. Wood Preservers Institute, Vienna, VA. p. 148-160.

Roliadi, H., C.Y. Hse, E.T. Choong, and T.F. Shupe. 2000a. Gluability of out-of-service utility poles. Forest Prod. J. 50(10):76-81.

Roliadi, H., C.Y. Hse, E.T. Choong, and T.F. Shupe. 2000b. Decay resistance of out-of-service utility poles as related to the distribution of residual creosote content. Forest Prod. J. 50(11/12):64-68.

Ruddick, J.N.R. and F. Cui. 1995; Extraction of toxic organic contaminants from wood and photodegradation of toxic organic contaminants. U.S. Patent 5476975.

Smith, G. 1992. Reduction, handling and burning of treated wood. Proceedings of the Treated Wood Life-Cycle Management Workshop, American Wood Preservers Institute, Vienna, Va. p. 139-143.

Solo-Gabriele, H.; T. Townsend, J. Penha, T. Tolaymat, and V. Calitu. 1999. Disposal end management of CCA treated wood. Proceedings American Wood Preservers' Association 95:65-74.

Vassou, Z, A. Satanakis, C. Koutsikopoulus, and J. Petinarakis. 1998. The rate of losses of creosote from power transmission poles during storage. International Research Group on Wood Preservation, 4th International Symposium on Wood Preservation. Document No IRG/WP/98-50101. Stockholm, Sweden. p.311-320.

Vick, C.B., R.L. Geimer, and J.E. Wood, Jr. 1996. Flakeboards from recycled CCA-treated southern pine lumber. Forest Prod. J. 46(11/12):89-91.

Webb, D.A. and D.E. Davis. 1992. Spent creosote-treated railroad crossties – alternatives and their reuse. Proceedings of the Treated Wood Life-Cycle Management Workshop, American Wood Preservers Institute, Vienna, Va. p. 109-138.