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TREATED WOOD WASTE MANAGEMENT

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1. Introduction

Management of post-use treated wood is one of the most difficult challenges for the wood preservation industry and is a main driving force in the substantial changes occurring in the industry. The three main wood preservative types used now in Canada are creosote (mainly railway ties and marine piling), pentachlorophenol (mainly poles, posts and timbers and chromated copper arsenate – CCA (all products but predominantly residential lumber products). Each preservative presents its own distinct and individual challenges for management at the end of its life cycle. Some of the specific difficulties with handling and disposal of post use treated wood are:

1. The material is widely dispersed in its use and there is generally not a mechanism for collection and transport of the material. Utility poles, railway ties and other industrial products are exceptions to this, since replaced material can be collected and brought to a central depot at time of replacement.
2. Treated wood is often commingled with other construction and demolition (C & D) waste and there is no efficient way to sort the materials (applies mainly to residential CCA treated wood). This inhibits the ability to manage C & D wastes as fuel for co-generation and use as horticultural mulch (42).
3. The amount of post-use treated wood becoming available is increasing (especially CCA treated residential lumber).
4. There are limited opportunities and options for recycling and reuse of treated wood. Potential options as a fuel source are constrained by regulations and complex permitting procedures in Canada.
5. There are pressures on landfill disposal related to shortage of landfill space and concerns for long-term environmental impacts of landfill disposal of treated wood.

2. Strategic Options Process for Wood Preservation and Development of a National Strategy for Waste Management of Post Use Treated Wood

Under the Canadian Environmental Protection Act (CEPA), substances defined as "CEPA-toxic" must be managed to minimize their releases to the environment and their effects on human health and the environment. Of the wood preservative components, the following substances have been designated CEPA-toxic: hexavalent chromium and arsenic (chromated copper arsenate), polynuclear aromatic hydrocarbons (PAH) and creosote impregnated wastes (creosote) and dioxin, furan and hexachlorobenzene micro-contaminants of pentachlorophenol. Management of CEPA-toxic substances within the wood preservation sector was addressed by a stakeholders group through the Strategic Options Process (SOP). As a result of these deliberations, a report was prepared (2) and two steering committees were formed to implement the recommendations of the report. The SOP identified issues of waste management and disposal of treated wood removed from service as the greatest potential source of release and exposure of these materials in the environment. A high priority was to develop a national strategy for the management of both industrial and consumer treated lumber removed from service.

As part of the SOP process, two reports were commissioned to address these issues:

1. National Strategy for the Management of Post-Use Preservative Treated Industrial Wood, 2001, By D. Konasewich, G. Brudermann and R. Stephens (27); and
2. Analysis of Consumer Lumber Waste Management Options. 2001. By P.A. Cooper (13).

Both reports will soon be available on the Environment Canada SOP Website.

http://www2.ec.gc.ca/sop/wood-bois/pubs/sor_e.htm

Much of the information presented here is derived from these reports.

3. How much treated wood is available for disposal in Canada?

3.1 Creosote

Virtually all creosote treated wood in service is in the form of industrial products such as railway ties (50:50 creosote and petroleum oil), poles or marine piling. While the amount of creosote treated wood has declined with increased use of pentachlorophenol and CCA, the usage has stabilized in recent decades at about 200,000 to 250,000 m^3 per year and we can expect relatively steady volumes of about 210,000 m^3 to be removed from service annually for the foreseeable future (46). This wood has reasonably good reuse and recycling potential because of the large size of the individual samples, the fact that they are not damaged substantially on removal and the suitability of creosote treated wood for energy recovery by co-generation.

3.2 Pentachlorophenol

Pentachlorophenol dissolved in a petroleum solvent is used mainly for treatment of industrial products such as utility poles, posts, timbers and land piling. The amounts in use have also stabilized somewhat and it is estimated that approximately 150,000 – 200,000 m^3 will be removed from service annually over the next few decades (46).

3.3 Chromated copper arsenate

The volumes of wood treated with CCA for both industrial and residential applications increased greatly from the early 1970's through to late 1980. As a result, it is predicted that the amounts coming out of service in both the USA and Canada will increase significantly over the next 2 decades (Table 1). Most of this volume is for residential construction (Figure 1). There will be a decline in volume eventually as CCA is replaced with alternative treatments for consumer lumber products after December 2003.

Table 1: Predicted removals of CCA treated wood (m^3/year) in the USA and Canada

	USA	Canada
1995	500,000	180,000
2000	1,600,000	570,000
2010	9,900,000	1,860,000
2020	15,000,000	2,280,000
Source	(12, 43)	(46)

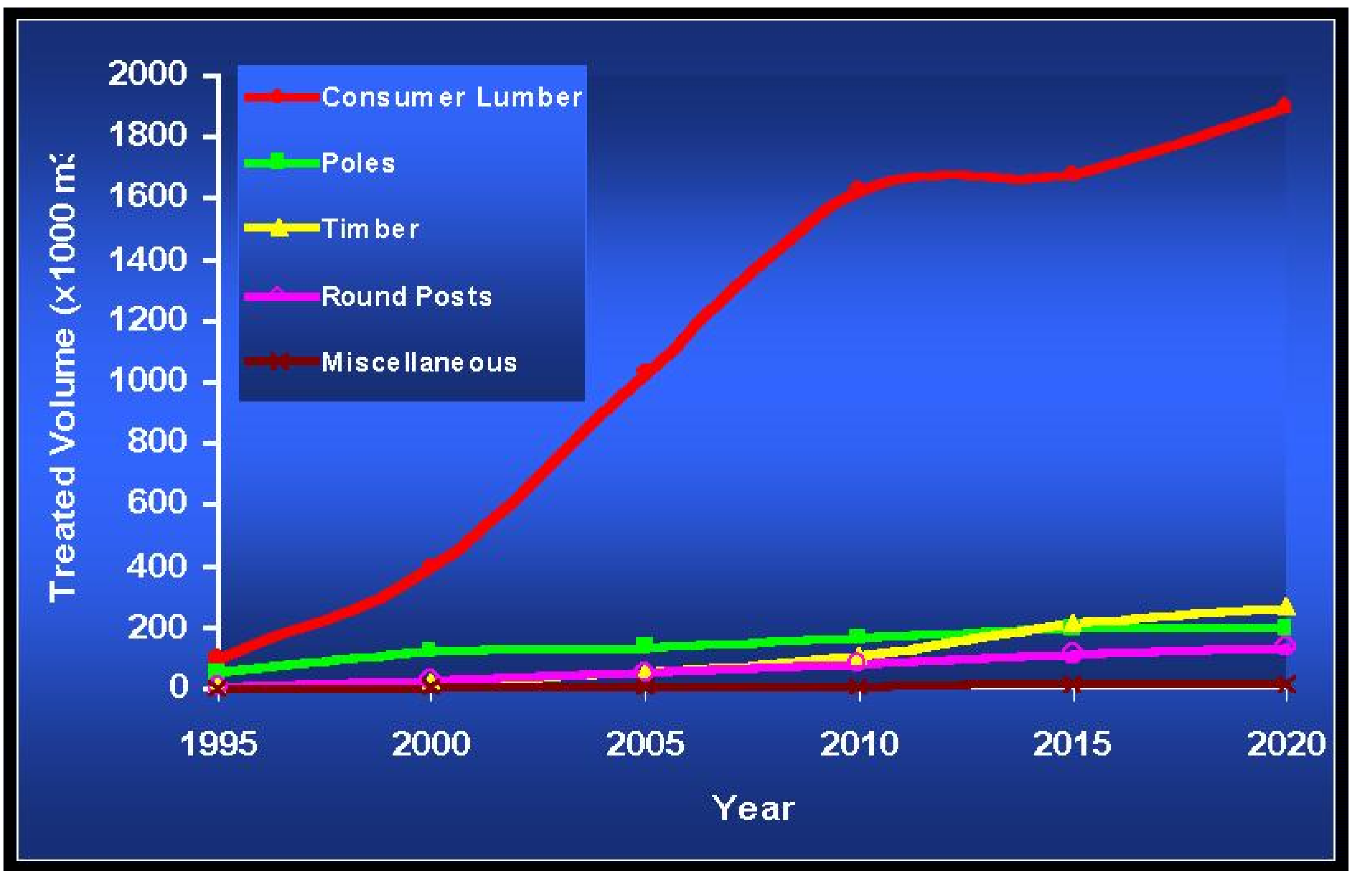

Figure 1: Predicted removals of CCA treated wood (m^3/year) in Canada (46)

4. Management of Post-Use Treated Wood

For the management of any waste product, there is a recognized hierarchy of preferred approaches:

Hierarchy of waste management

- Waste abatement or elimination
- Waste reduction or modification
- Waste reuse
- Waste recycling
- Waste treatment
- Waste disposal

While individuals may interpret these categories differently, we can generally consider the following approached for treated wood.

4.1 Waste abatement or elimination, reduction and modification refers to practices that reduce or eliminate the availability of waste material. Extreme examples are substitution of treated wood for alternative materials such as steel, concrete, plastic lumber, chemically modified wood (e.g. heat treatment) and naturally durable species to reduce or eliminate treated wood from the waste stream in the long term. The Strategic Options Report (2) stresses the importance of full life cycle analysis of alternatives to ensure that they have better environmental effects over the entire life cycle before advocating such approaches. However, it is clear from the growth in plastic lumber production, that there will be some substitution for treated wood products used in residential construction by this material.

Another possibility for substitution is to use alternative wood preservatives with better options for recycling or other preferred disposal options. For example, some US utilities have shown renewed interest in creosote treated poles because of the potential to recover energy in co-generation processes at the end of their life cycle. Presumably, new preservative systems such as synergistic mixtures of organic preservatives and arsenic-free waterborne systems such as ACQ and copper azole have greater potential for recycling for energy recovery than, for example, CCA. Again, it is important that decisions to switch to alternative preservative systems should be based on full life cycle analyses.

Another approach to abate or reduce the amount of post-use treated wood is to ensure as long a service life as possible for treated wood. It was reported (30) that the average age of a deck in some parts of the USA was about 9 years. Decks were removed after a short service life for reasons of premature deterioration or loss in appearance. The average life can be extended through:

1. Good quality control procedures at the treating plant to ensure that wood is treated to appropriate standards to ensure adequate service life (but not over-treated).
2. Good training of plant operators to ensure the above.

3. Proper installation practices, including appropriate uses of different species and levels of treatment and use of an end-cut preservative to protect untreated wood exposed during construction and framing.
4. Good design of structures to use full pieces of wood or pre-fabrication of structures to avoid waste pieces.
5. Maintenance of structures to maximize their service life, for example by:
   - Use of coatings and water repellents to maintain the appearance quality longer and avoid replacement for aesthetic reasons;
   - Use of remedial treatments such as borate based rod or liquid treatments, bandage wrap treatments for poles and fumigant treatments for poles and large timbers to extend their lives.

4.2 Re-use usually refers to use of a product as removed from service, without reprocessing, but by some definitions may include some minor processing, such as re-treatment.

Industrial products such as railway ties and poles have the greatest potential for re-use. Both can be re-used for their original use, usually for less critical applications such as on secondary rail lines or for lower service pole lines. This requires a grading system to classify material removed from service for re-use. It is most feasible for utility companies, as poles are often removed for other reasons than loss in physical condition (e.g., for road widening, upgrading of lines etc.). An evaluation of about 450 poles removed from service by Bell Canada in Quebec and Ontario indicated that about 8 % of the poles could be re-used for poles (16). Konasewich et al (27) reported the use patterns in Tables 2 and 3 for ties and poles in Canada. The predominant re-use for ties has been, and is still, for landscaping purposes. The re-use pattern for poles is changing and moving down rather than up the waste management hierarchy, mainly because of the reluctance of utilities to give away or sell poles for re-use due to liability concerns.

Table 2: Use of ties removed from service in Canada (27)

Number removed from service (2001)	1,210,000
Re-use	**% for use**
Reuse in line	7
Landscaping	54
Open Burn	2
Energy Recovery	10
Landfill	12
Storage (yard or rail-side)	15

Table 3: Use of poles removed from service in Canada (1996 vs. 2000) (27)

Year	2000	1996
Number removed from service	95,000	115,000
Re-use	**% for use**	**% for use**
Reuse in line	13	9
Sale/Donation for reuse or recycling	30	79
Other Products	28	8
Energy Recovery	4	0
Other recovery or loss	12	0
Landfill	13	4

Residential products have very little potential for re-use, unless still well-performing structures are salvaged by dismantling without damage. This will be an insignificant factor in the management of this material.

4.3 Recycling

(i) Reprocessing into solid wood products

Industrial products can be recycled through reprocessing, for example, by cutting poles into posts and sawing poles or timbers into lumber. Spent poles can be converted into high quality square guiderail posts and construction lumber (11,16) and there are currently several commercial units recycling poles into lumber in Canada (27). For products like butt treated cedar poles, the lumber is essentially preservative-free and can be used as untreated naturally durable lumber. For other species, the products will contain some preservative and often require re-treatment for appropriate industrial uses. While this material can be re-treated (16) it raises the possibility of having material containing two different preservatives, which may complicate ultimate disposal.

(ii) Derivation of fuel from treated wood

It is generally accepted that creosote treated wood should be accepted as a fuel for boilers, co-generation plants and cement kilns since the combustion of creosote results in similar emissions as the combustion of coal. With proper combustion temperatures and burner residence times, emissions of PAH's and other VOC's should be negligible.

The combustion of pentachlorophenol treated wood is more problematic because of the potential for production of dioxins and furans during combustion. However, with properly controlled combustion conditions, pentachlorophenol and its micro-contaminants can be mineralized to water, CO_2 and HCl. This wood can also be used as fuel in cement kilns with acceptable stack emissions (3,31). However, the amounts of penta treated wood that can be accepted in cement kilns is limited by the amount of chloride allowed in the cement clinker (3).

Combustion of CCA treated wood is most difficult because of the volatilization of arsenic under combustion conditions and the presence of significant arsenic and chromium in the ash, which render it a hazardous waste. While heat is recovered from the process, it can best be described as "waste reduction and modification" rather than recycling. Considerable work is underway to evaluate pyrolysis processes designed to recover CCA components (19). One opportunity for recycling CCA treated wood is in cement kilns where the inorganic components in the stack can be removed by scrubbing and the remainder are incorporated in the cement clinker. The arsenic and copper in the clinker are well stabilized, but the amount of chromium permitted is limited (3) because it is less stable in the high pH environment and may leach hexavalent chromium from the cement. This specified limit in chromium content means that only about 1 – 1.5 million cubic meters of CCA treated wood coming out of service could be recycled if all Canadian cement kilns accepted this material to their capacity (13).

There are several barriers and constraints to the recycling of spent treated wood for energy recovery:

- In most cases wood must be ground to fine particles, requiring a lot of energy and decontamination of the wood to remove metal etc.
- It is very difficult to get permits for treatment of waste material by burning or incineration.
- The cost of collection and transport of material is high.

(iii) Extraction of preservative components for recycling of preservatives and/or wood fibre

The organic wood preservatives can be removed from wood by solvent extraction, but this has never been considered as a waste management approach. Pentachlorophenol can be made soluble in water by reaction with alkali such as sodium hydroxide. This approach has been tried at a commercial scale in combination with biological treatment (36) but did not prove to be cost effective.

Inorganic preservatives can be more-or-less extracted by a number of solvents, such as strong acids or bases (21,26), organic acids (24,25) and oxidizing agents such as sodium hypochlorite and hydrogen peroxide (25). The latter treatments are most promising for CCA since the chromium is re-oxidized to the hexavalent state and it can be recycled in CCA solutions. This approach is costly (more than $300.00 per tonne) and there is always a small amount of residual contaminant in the wood fibre. Many variations to this approach have been evaluated, including electo-dialysis to promote removal from the wood (37) steam explosion (41) and biological treatments to produce natural organic acids to extract components (with (5,8,9) or without (7, 35,39,45) additional solvents), none of which are economically feasible at this time.

(iv) recycling of treated wood into composite products

There have been many laboratory studies and limited pilot scale studies to evaluate the feasibility of making composite products from treated wood. Railway ties have been chipped and reconstituted as composite ties (CedriteTM) on a commercial basis (10), but this is not done commercially at this time.

Conventional wood based composites (OSB, particleboard, MDF etc)

There have been many studies that demonstrate that wood based composites can be made with CCA treated wood (4,6,33,38,40,60,61,62). In some cases, adhesive bonding is impaired unless resins are especially formulated for the product. There is some justification for trying to enhance the durability of oriented strand board (OSB) products, because their applications often make them susceptible to decay. However, the raw material is not conducive to producing the preferred thin strands due to the low moisture content, contaminants and size and shape of most treated wood (lumber not large round pieces). Thus there is little potential for such products. Particleboards and medium density fiberboard products can be made with spent waterborne treated wood, but except for certain applications where dry-wood insects are a problem, there is no justification for incorporating treated wood to enhance durability of these products. Use of composite products simply to consume unwanted treated wood is not acceptable.

Wood cement composites

There are several benefits to incorporating spent CCA treated wood in wood particle cement boards and other wood cement composites. CCA treated wood is more compatible with Portland cement than is untreated wood and CCA treated furnish results in products with better physical and mechanical properties (22,23,55). Furthermore, the treated wood imparts better decay resistance to the composite (23). A further advantage is that copper and arsenic components of the treated wood are almost completely stabilized by the cement matrix and leaching of these components from the composite is negligible (23). However, some of the chromium can be oxidized to hexavalent chromium in the cement matrix resulting in slight leaching of CrVI (14).

Wood plastic components

The production of thermoplastic resin/natural fibre composites is growing rapidly (more than 20% per year) as a replacement for treated wood and other products for decking and other low structural capacity products. These products are formed by co-extrusion of 40-70 % wood or other natural fibre particles with high-density polyethylene or polypropylene. It is becoming increasingly clear that wood plastic components can deteriorate significantly in service as a result of fungi (29,32). The product could be made more durable by the incorporation of treated wood furnish as the natural fibre component. The blending and extrusion properties are high temperature and the organic preservatives would likely volatilize too much to be practical, despite the potential for high polymer compatibility with the non-polar preservatives. CCA treated wood could be blended with the polymers and there is some indication that the less polar treated wood surfaces are more compatible with plastic than untreated wood. The main barrier to this application is the resistance of the wood plastic manufacturers to use treated wood when they are marketing their products as an alternative to treated wood.

4.4 Waste treatment

It is possible to extract the CCA components from treated wood by passing it through metallurgical processes. In Finland (28,34,55) such processes have been developed to recover the CCA components either as feedstock for CCA manufacture or for other materials.

It is also possible to incinerate treated wood in special waste facilities such as the waste incinerator at Swan Hills, Alberta. This treatment is extremely costly, and no energy or other benefit is recovered.

4.5 Landfill disposal

Landfill disposal is considered the least desirable waste management option. It is a waste of a potential resource and results in excessive consumption of scarce landfill space. At this time, all types of treated wood are accepted for landfill disposal, although some specific landfill owner/managers resist accepting treated wood.

The acceptability of materials containing pesticides and other toxic substances for disposal in normal landfills is regulated through a leachate toxicity test such as the Toxicity Characteristic Leachate Procedure (TCLP). This is a laboratory procedure whereby the material is ground to pass a 10 mm screen and extracted with acidified water. If the leachate concentration for the specified substance is below a prescribed TCLP level (usually set at 1/100 of the drinking water standard for the substance) the material is considered acceptable for normal landfill disposal. The recently revised Ontario Regulation Oreg. 558/0 (1) TCLP criteria and the Schedule of hazardous constituents under the Inter-provincial Movement of Hazardous Wastes and Hazardous Recyclable Materials (Pre-Gazetted for comments, 2002) raise concerns that some treated wood could be listed as hazardous waste. The criteria listed are more stringent than EPA levels for some preservative components and could capture some treated wood under the regulations. For example, Oreg. 558/0 TCLP limits are 2.5 ppm for arsenic (vs 5.0 under EPA) and 6 ppm for pentachlorophenol (vs 100 ppm under EPA). The results of published TCLP test evaluations and the estimated probabilities of not meeting TCLP criteria are shown in Table 4.

It is clear that some treated wood could be listed as hazardous waste if the above criteria are strictly adhered to. There are many reasons why treated wood should be exempted from these considerations, including:

- If treated wood were designated hazardous waste there are huge volumes now in service in Canada which would have to be disposed of at hazardous waste sites and there is not enough capacity to do this and the cost would be prohibitive. The following amounts of treated wood are estimated to be in service (47):
  Creosoted ties 280 million cubic feet (9 million cubic meters)
  Poles (all preservatives) 300 million cubic feet (10 million cubic meters)
  Consumer lumber 440 million cubic feet (15 million cubic meters)
  Other 114 million cubic feet (3.6 million cubic meters)
  Total 1,134 million cubic feet (37.6 million cubic meters)

- The TCLP procedure is not appropriate for treated wood since it assumes that the material may break down physically in the landfill and so requires that it be ground to pass a 10 mm screen for the test.

Table 4: Summary of TCLP studies

Reference	**Product**	**Sample description**	**Preservative component**	**TCLP Level ppm Ave. Max**	**O-Reg 558/0 level (ppm)**	**Probability of "passing" TCLP test**
(17)	Penta Poles & crossarms	Pass 9.5 mm mesh	Penta Cresols 2,4,6 trichlorophenol	2 7.8 3.4 0.06	6 200 0.50	95 % +
(49)	Penta SYP poles Crossarms	Pass 9.5 mm mesh Pass 9.5 mm mesh	Penta penta	90th percentile 4.2 90th percentile 3.0	6 6	95 % + 95 % +
(18)	Creosote poles	Pass 9.5 mm mesh	Cresols	1.7 15	200	100 %
(20)	Creosoted ties	Pass 9.5 mm mesh	p-Cresol	7.5	10	90 % +
(54)	Creosoted poles (SYP)	Pass 9.5 mm mesh	Cresol Benzene Pyridine	9.0 0.20 0.6	200 0.50 5.0	100 % 99 % + 100 %
(54)	CCA poles	Pass 9.5 mm mesh	Arsenic Chromium	4.3 0.93	2.5 5.0	~50 % 100 %
(50)	CCA SYP Lumber – fresh treated	Sawdust Chips Sawdust Chips Small blocks Large block C&D mulch	Arsenic Arsenic Chromium Chromium Arsenic Arsenic Arsenic	7 12.5 3 10 2.5 4 <1 3 1.5 4.5 1 3 < 0.5 ppm	2.5 5.0 2.5 2.5 2.5	 ~50 % ~100 %
(15) Leachate extraction vs whole ties	Creosoted ties	Pass 9.5 mm mesh Whole ties (h rain, recycled)	o-cresol m-cresol o-cresol m-cresol	0.01-0.61 0.01-0.34 ND – 0.03 ND-0.01	200 200 200 200	100 %

*EP toxicity test

Wood will maintain its size and geometry in a landfill and therefore present a much lower surface area for leaching per unit mass or volume of wood. Studies conducted on CCA wood (50) and creosoted ties (15) demonstrate that as the size of the wood sample increases, the TCLP concentration decreases (Table 5).
Studies on the surface leaching of fresh CCA treated wood continuously exposed to water at pH 5 (TCLP conditions) show arsenic emission rates in the order of 5 µg/cm^2/day or 3.75 µg/cm^2 for the 18 hour TCLP test (44). Considering the low surface area to volume

ratios of different wood products, the relative emissions from whole wood pieces will be much lower than for the TCLP test (Table 5).

- The treated wood SOP is developing a management strategy for post-use treated wood that encourages the reuse, recycle and energy recovery options. Designation of treated wood as hazardous waste would restrict any management options proposed by the SOP.

Table 5: Relative surface areas and size effect on expected TCLP results

Specimen	**Dimensions**	**Pieces/m^3**	**Surface area/volume (cm^2/cm^3)**	**Surface area for TCLP test* (cm^2)**	**Expected TCLP Arsenic concentration** (mg/L)**
TCLP	9mm cube	1,370,000	6.67	1334	2.5
Fence board	1”X6”X6’	251	1.20	240	0.45
Deck board	2”X6”X8’	94	0.68	136	0.25
Class 4-35 pole	350mm butt, 150 mm top 10m long	0.88	0.069	13.8	0.025

* based on 100 g or 200 cm^3 of sample
** based on estimated emission rate of 3.75 µg/cm^2 and 2.0 L liquid

5. Strategy for the management of post-use treated wood

The two reports commissioned to address a national strategy for managing spent treated wood suggest the following approaches:

5.1 General

- Consider post-use treated wood a resource not a waste
-

5.2 Apply relevant abatement approaches discussed above

- Ensure adequate training and quality control at treating plants to ensure adequate but not excessive treatment;
- Encourage appropriate installation and maintenance practices to ensure longest service life

5.3 Stewardship

- Maintain identity of treated wood; if reprocessed for example into composites, it must be identified as containing treated wood;
- Control sale or transfer of treated wood to ensure its appropriate reuse or recycling;
- If extract, do so for re-use not disposal

5.4 Develop Political Commitment for the issues

- Ensure government recognition of benefits of treated wood
- Government must assume some responsibility for life cycle management;
- Resolve and minimize regulatory barriers for recycling options where appropriate. Make permitting for co-generation, boilers and cement kilns more feasible and accepted by provincial regulators;
- Stimulate development of better options through research and development and Technology Transfer.

5.5 Consider Regulatory options

- Discourage landfill disposal to encourage technological options higher up the waste management hierarchy;
- Simplify the registration procedures for alternative preservatives;
- Apply a disposal fee (like a tire tax) on treated wood - User pays;
- Implement "extended producer responsibility" to require producers to take responsibility for ultimate disposal. This will lead to stronger incentives to produce long-lived products and products with more waste management options.

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