TRENDS IN TIMBER PRESERVATION—A GLOBAL PERSPECTIVE

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COGGINS, C. R. 2008. Trends in timber preservation—a global perspective. Durability of timber can be conferred by the selection and application of effective preservative treatments or by processes that modify the wood structure and render it resistant to insect and fungal attack. Environmental, and health and safety concerns have led many governments to regulate the use of wood preservatives. Older types that have served the industry well for decades have in some areas been withdrawn from the market under the influence of such regulations and new formulations have taken their place. The fact that new preservatives are available in the markets where older types have become less acceptable reflects an industry ahead of, not driven by, regulations and environmental pressures. Sustainability and carbon footprint issues are driving a new approach to the prediction of service life of building components and this is also influencing the direction of timber preservation.

Keywords: Durability, standards, service life, Use Classes, sustainability, carbon footprint, disposal

COGGINS, S. R. 2008. Trend pengawetan kayu—satu perspektif global. Ketahanan kayu boleh dicapai melalui pemilihan dan penggunaan bahan awet yang berkesan atau melalui proses yang mengubah suai struktur kayu untuk menjadikannya tahan kepada serangan serangga dan kulat. Kebimbangan tentang alam sekitar serta kesihatan dan keselamatan mengakibatkan kerajaan mengawal penggunaan bahan awet kayu. Di bawah peraturan baru, bahan awet lama yang telah digunakan dalam industri perkayuan berdekad-dekad lamanya ditarik balik daripada pasaran di beberapa tempat dan digantikan dengan formula baru. Kehadiran bahan awet baru dalam pasaran dan kurangnya permintaan terhadap bahan awet lama mencerminkan industri yang tidak dipengaruhi, malah mendahului peraturan dan tekanan alam sekitar. Isu kewujudan dan jejak karbon memberi pendekatan baru kepada ramalan hayat khidmat komponen bangunan. Semua ini mempengaruhi hala tuju pengawetan kayu.

INTRODUCTION

Wood is a superb material and the only truly sustainable resource for construction. Pressure from consumers and environmental groups has made certified sources of sustainable timber the preferred choice for many specifiers, builders and projects. Timbers from certified sources are widely used in construction and for many other situations where their natural durability is often insufficient to ensure confidence in an economic service life.

Durability can be conferred, however, by the selection and application of effective preservative treatments or by processes that modify the wood structure and render it resistant to insect and fungal attack. Environmental, and health and safety concerns have led many governments to regulate the use of wood preservatives. Older types that have served the industry well for decades have in some areas been withdrawn from the market under the influence of such regulations and new formulations have taken their place.

Preservative manufacturers have a long tradition of being at the forefront of research and development. Particularly for the protection of timber in the higher hazard or safety-critical uses, preservative development time may be measured in years. The fact that new preservatives are available in the markets where older types have become less acceptable reflects an industry ahead of, not driven by, regulations and environmental pressures.

Decades of research and development also characterize the wood modification sector and a look at trends in wood protection must include a review of modified wood, its potential and its role in maintaining and extending the market for timber where durability is a requirement.

National and international standards have played a major part in the assurance of quality and fitness for purpose of treated timber. Sustainability and carbon footprint issues are driving a new approach to the prediction of service life of building components that includes product-specific assessment of performance replacing or at least complementing generic standards. This is also influencing the direction of timber preservation research.

Global trends are certainly discernible but it is important to understand how and at what speed they may influence timber preservation regionally and locally.

Standardization of Use Classes

A global perspective requires a framework that can be applied to all regions. Happily following an initiative by Technical Committee 38 of CEN (the European Standards Commission), the International Standards Organisation has developed a standard framework of Use Classes potentially applicable to all situations in all regions. This has been published as a final draft for voting by national standards bodies affiliated to ISO. It is likely the draft will be approved and if so the standard will be published as ISO 21887 *Durability of Wood and Wood-based Products—Use Classes*. Table 1 shows the draft framework.

Clearly unless a wood preservative has a very broad spectrum of activity its use will have geographical limits as exemplified in the subclasses in the table. Thus a preservative suitable for Use Class 2 in the temperate, currently termite-free climate of the UK may be inadequate for the same Use Class in regions with termite-infested zones, or could be suitable but at a higher retention and/or penetration. Recognising this, the ISO framework enables Use Class 2 to be further classified as 2A and 2B respectively. This is useful for regional comparisons but national application of Use Classes can be simpler if the biological challenges to timber in service include only some of the organisms in the ISO table. Thus as an example British Standard 8417:2003 (amended 2007) *Preservation of Timber—Recommendations* uses only Use Classes 1, 2, 3.1, 3.2, 4 (all without termite risk) and 5.

Characterization of the performance of preservatives

Having a framework for defining service conditions for timber, where the natural durability of the timber to be used is insufficient for the intended Use Class, its durability must be improved to match the specifiers' and customers' requirements. A common framework for assessment of performance then becomes the next aim. In many countries with a history of preservative treatment, a framework of test methods for the assessment of preservatives has emerged. Test methods alone, however, are insufficient to determine performance. The results of tests with treated timber have to be interpreted and used to indicate the ability of a preservative to protect timber in different Use Classes. For most Use Classes, tests with decay fungi and wood-destroying insects have to be carried out. How do we interpret the results of the tests?

An example of a regional agreement on a common basis for performance assessment is found in the European Standard EN 599. This allocates a range of standard test methods to each Use Class and includes for each the rules for interpreting the results. For each test the performance relative to a known preservative is established and the loading of preservative required to achieve the necessary performance is the 'biological reference value' (brv). Thus for any preservative, a range of brv's will be established from the tests carried out for each Use Class. EN 599 defines the highest brv in each Use Class as the 'Critical Value' (CV).

For any preservative then, if a CV has been established for each Use Class have we done all we need to do to confidently market the preservative? After all, tests have established that with that much preservative in the timber, the timber will be protected against the known biological agents that may attack the wood in service. The answer is that the process has only just begun!

Service life prediction

One of the most important questions for specifiers and users of timber products is "how long will they last in service?". For some wood and wood-based commodities perhaps only a very short life is required––we can think of plywood shuttering used for concrete structures which has a life measured perhaps only in days or weeks. On the other hand, timber poles for telecommunication and electricity distribution must have a life measured in decades and wood used for the construction of houses perhaps the longest service life of all—in Europe the normal life required of components of a building has been established as 60 years.

Table 1 Use Classes and Subclasses, typical uses and occurrence of biological agents (from ISO/FDIS 21887:2007)

Class	Service condition		Typical use	Biological agent	
1	Interior, dry	Framing roof timbers	Insects	A	Wood-boring beetles
				B	As 1A plus dry-wood termites
2	Interior, damp	Framing roof timbers	Wood boring beetles, disfiguring fungi, termites	A	As 1A plus decay fungi
				B	As 2A plus termites
3	3.1	Exterior, above-ground protected from the weather	Exterior joinery	Wood boring beetles, disfiguring fungi, decay fungi, termites	
	3.2	Exterior, above-ground unprotected from the weather	Cladding deck boards		
4	4.1	In-ground	Fence posts Landscape timber	As 3 plus soft rot fungi	
	4.2	In-ground, severe, fresh water	Cooling tower fill		
5	Marine	Boat hulls, marine piles, jetties	As 4 plus marine borers	A	Teridinids plus *Limnoria*
				B	As 5A plus creosote-tolerant *Limnoria*
				C	As 5B plus pholads

A higher Use Class may be assigned if it is anticipated that service conditions can arise that result in a higher risk to the timber than that normally experienced by the typical uses listed.
It might not be necessary to protect against all biological agents listed, as they might not be present or economically significant in all service conditions in all geographic regions.

The UK has one of the longest traditions of including service life of treated timber commodities in its standards. The latest British Standard to include service life is BS 8417. This standard forms the basis of the recommendations in the UK Wood Protection Association manual *Industrial Wood Preservation—Specification and Practice*. These specifications define the combination of penetration and CV required to ensure a service life of 15, 30 or 60 years for wood and wood-based products in each Use Class. Table 2 is an example of how this works in practice. For preservatives which performance has been established in EN 599 tests, this sets out the combination of preservative retention (expressed as a multiple of the CV) and penetration (expressed as a 'P' value taken from EN 351–1).

It will be seen that a further criterion, service factor, affecting treatment recommendations is included in Table 2. This is a long-established system of assessing how confidence in the reliability of timber components in service may be used to decide if the treatment should be more intense. Table 3 sets out these service factors and their definition.

So we see in these tables a workable system of service life prediction that has served the UK market well for many years. However, on the international stage a 10-part ISO standard (ISO 15686) exists that sets out a framework for service life prediction and this framework is being considered as a basis for service life prediction for treated timber at regional level in the EU with, one must conclude, implications for standards globally. This standard includes a range of factors that could be taken into account in service life prediction, allowing a formula to be used to derive an estimated service life. This approach is summarised by Eglund (2006) and the factors are shown in Table 4.

Table 2 UK Service Life designations for timber commodities in Use Classes 1 to 5 (based on the Wood Protection Association manual) for preservatives which performance has been established in EN 599 tests

	Component (group number and description)	Use Class	Service factor	Desired service life (years)											
				15				30				60			
				Preservative recommendations				Preservative recommendations				Preservative recommendations			
				Permeable wood		Resistant wood		Permeable wood		Resistant wood		Permeable wood		Resistant wood	
				Penetration	Retention	Penetration	Retention	Penetration	Retention	Penetration	Retention	Penetration	Retention	Penetration	Retention
1	Internal joinery	1	A	No treatment required				No treatment required				No treatment required			
2	Roof timber dry	1	B	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1
3	Roof timbers dry (*Hylotrupes* area)	1	D	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1
4	Roof timbers (risk of wetting)	2	C	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1
5	External walls/ground floor joists	2	C/D	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1	P1	CV1
6	Sole plates (above DPC)	2	D	P1	CV1.5	P1	CV1.5	P1	CV1.5	P1	CV1.5	P1	CV1.5	P1	CV1.5
7	Fence rails (coated) external joinery (non-load bearing, coated) and cladding (coated)	3.1	C/D	P2	CV1	P2	CV1	P2	CV1.25	P2	CV1.25	P5	CV1.5	P5	CV1.5
8	Fence rails, deck boards and joists, external joinery (non-load bearing, uncoated) and cladding (uncoated)	3.2	C/D	P8	CV1	P2	CV1	P8	CV1.25	P4	CV1.25	Note 2			
								For Use Class 4 > 15-year life see Note 1							
9	Fence and deck posts	4	C/D	P8	CV1	P4	CV1	P8	CV1.5	P6	CV1.5	Note 2			
10	Poles	4	D	P8	CV1	P7	CV1	P8	CV1.5	P8	CV1.5	Note 2			
11	Sleepers	4	D	P8	CV1	P8	CV1	P9	CV1.5	P9	CV1.5	Note 2			
12	Timber in fresh water	4	D	P9	CV1	P9	CV1	P9	CV1.5	P9	CV1.5	Note 2			
13	Timber in salt water	5	D	P9	CV1	P9	CV1	P9	CV1.75	P9	CV1.75	Note 2			
14	Cooling tower timbers (fresh water)	4	D	Note 2				Note 2				Note 2			
15	Cooling tower timbers (salt water)	4	D	Note 2				Note 2				Note 2			

Notes: 1. For Use Class 4 where service life greater than 15 years is required, laboratory data may not accurately predict the performance of the treated commodity over a prolonged period of service. Data from field trials may provide additional information and confidence in service life prediction. Wood preservative suppliers should be consulted.

2. Treatment recommendations cannot yet be given for these Use Class and service life combinations as the preservatives have not been in service or tested for long enough. Where such combinations are desired, consult preservative suppliers for recommendations. P9 Penetration Class will normally be required.

Table 3 Service factors

Service factor code	Description of risk and consequences of failure	Need for treatment of timbers as natural durability is insufficient for the Use Class/ service life combination
A	Negligible risk of failure	Unnecessary
B	Where risk of failure is low and preservation can be regarded as an insurance against cost of repairs, and/or where replacement of timber or remedial action is not difficult or expensive	Optional
C	Where risk of failure is high and/or where replacement of timber or remedial action is difficult and expensive	Desirable
D	Where risk of failure is very high and/or where failure of timber components would result in serious danger to structure or persons	Essential

Table 4 Factors affecting service life (after Eglund 2006)

Factor	Designation
A	Quality of components
B	Design
C	Workmanship
D	Indoor environment
E	Outdoor environment
F	Usage conditions
G	Maintenance

Eglund includes the formula from ISO 15686 that shows how the factors might be used:

Estimated service life = Reference service life × A × B × C × D × E × F × G

The output from such a system has the potential to indicate service life to a very precise degree. However, the EU research group convened under the COST E37 programme (http://www.bfafh.de/cost37.htm) that includes service life prediction in its programme is moving towards recommending the need to define broad service classes, equivalent to design lives, rather than calculate precise years of service as tends to be the result of applying the ISO 15686 system fully. This seems sensible and a further refinement of the UK service factor system could be adopted in the EU. This could then provide a model for service life prediction in other regions.

Sustainability

As well as deriving timber itself from sustainable (certified) sources, users are beginning to demand that the process of conferring durability on timbers when required also has sustainability credentials. In this context Suttie (2005) defines sustainability in this way:

"The enhancement of wood durability shall meet the needs of the present without compromising the ability of future generations to meet their own needs. The technologies used shall protect the health and vitality in the long-term of the economy, the environment and our quality of life".

Many of the trends perceptible in the global wood preservation market include elements that contribute to improved sustainability. These include environmental protection measures, the regulation of wood preservatives at national and regional levels and the regulation of disposal. The Green Guide to Housing Specification (Anderson & Howard 2000) is helpful here, declaring, "The use of timber preservatives in situations where timber, left untreated, would be likely to decay, greatly extends the life of the timber (with modest additional environmental impact), thereby reducing replacement intervals and its total impact over a 60-year life. Factory application of preservatives both ensures their efficacy and minimises any risk of environmental damage".

Regulation of wood preservatives

In many countries, regulations prevent the marketing of wood preservatives unless they have been assessed and approved for safe use by the general public, professional operatives or industrial plant operators. In some EU countries such regulations have been in place for 20 years or more.

'Safe use' in this context may mean only 'safe to use' by the user type for which approved, or, as in the case of the most recent regulations introduced at regional level (in the EU), it may mean 'safe to use' and 'safe for the environment (i.e. Use Class) for which it is approved. The EU regulations (in accordance with the Biocidal Products Directive (EU 1998)) have introduced a new and difficult system that has dramatically changed the market for preservatives and treated timber.

In addition, the EU has a regulatory procedure (now incorporated into the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulations (EU 2006) that can be applied to individual substances and products. These regulations have introduced specific restrictions on pentachlorophenol, arsenic and creosote and timber treated with those substances over the past 25 years.

The immediate impact of these regulations has been to remove from the market a number of substances used by the wood preservation industry in Europe for many years. These include:

(1) Chromated copper arsenate (CCA) (September 2006)
(2) Creosote (for use by the general public — July 2003)
(3) Pentachlorophenol (PCP) (for use by the general public — January 1993) (No approvals for wood preservatives containing PCP remain in Europe now)
(4) Copper naphthenate (effective August 2008)
(5) Oxine copper (effective August 2008)
(6) Chromium-containing preservatives (e.g. chromated copper borate (CCB), chromated copper phosphate (CCP)) (September 2006)

The position of chromium is under debate and it may be possible to continue to market preservatives such as CCB and CCP if the chromium is present as a fixative with no biocidal activity.

It should be mentioned that while the EU has concerns about the safety of, for example, CCA, its complete withdrawal from the market is not due to a ban being introduced by the authorities because of unacceptable safety risks. Restrictions were placed on where wood treated with arsenic could be used. Permitted uses included mostly Use Class 4 timbers; while the performance of CCA in Use Class 4 was well established and appreciated by users of such timbers (for example highway fencing), the value of these remaining uses for CCA-treated timber was insufficient for the manufacturers to commit to supporting CCA through the costly new regulatory procedures. In the absence of that support, approvals were withdrawn on a procedural, not a safety, basis.

The active substances in all wood preservatives on the market in the EU are being re-assessed under the new rules now and the industry is waiting for the decisions. We already know that dichlofluanid will be listed for use in wood preservatives but many more active ingredients are being assessed. Some insecticides and fungicides new to wood preservation are also being assessed under the new rules. The decision to apply for approval is a difficult one not least because of the cost of applying and developing the necessary data. Leithoff and Blancquaert (2006) estimate the cost of the notification for approval of an existing active substance to be up to 6 million euros; the cost of application for approval of a preservative containing that active substance up 1.4 million euros.

Globally we see regulations on approval of wood preservatives evolving in similar ways to the EU. While it is by no means certain that all countries or regions will follow the EU in its decisions, we can already see pressure on a number of preservative types:

(1) CCA—restrictions in the USA and EU
(2) Creosote—restrictions in the EU and USA
(3) Preservatives based on a volatile organic solvent (VOC) carrier—restrictions in the EU over release of VOCs to the atmosphere requiring licensing of the larger treatment plants are making it increasingly costly to use solvent-based preservatives.

We see the following preservative types emerging to fill gaps in the market resulting from restrictions on existing products:

(1) Copper-organic preservatives (based on copper with borates and organic fungicides

and insecticides such as azole compounds and permethrin). These are replacing or have already replaced CCA, CCB and CCP preservatives in some markets.
(2) Microemulsion water-dilutable concentrates with organic fungicides and insecticides
(3) Water and solvent-based coloured preservatives for the DIY market replacing creosote.

Figure 1 indicates the trend in UK consumption of preservative treatments from 1999 till 2006 and is an indicator of changes across the European region.

For the time being these and other newer preservatives important in national or regional markets, together with the older types where regulations do not yet prevent their use, provide the means of increasing the durability of timbers, when necessary, for each Use Class.

Looking to the future, papers presented at the annual meetings of the International Research Group on Wood Preservation (IRG) illustrate an exciting range of new technologies that could be applied in the field of wood preservation. These include nanobiocides (biocides with a particle size from 1 to 100 nanometres) (Clausen 2007) and silver chemistry (Ellis *et al.* 2007). Whether they will reach the market depends on the success of their technical development, the manufacturer's assessment of market size and return on investment in development and registration and the likelihood of them being accepted for approval under their local regulations.

Modified wood

Although one may argue that preservation of wood by impregnation with preservative chemicals is indeed perhaps the original form of 'wood modification', this term is increasingly being applied to technologies that mostly aim to achieve improvements in properties of wood:
(1) Resistance to decay
(2) Dimensional stability
(3) Resistance to effects of weathering
(4) Adhesion of coatings
by processes and technologies that do not impregnate the wood with biologically active substances but which alter the physical and/or chemical nature of wood to improve these properties.

Several processes that are based on heating wood under carefully controlled conditions to alter its chemistry are at the forefront of the modified wood programme in terms of commercial exploitation. Taking one commercial example, ThermoWood® production has reached 30 000 m^3 per annum in Finland and the majority is exported to other EU countries. Wood is heated to either 190 or 212 °C for around three hours. The higher temperature is required for greater durability.

The most obvious characteristic of such wood is its darker colour (that may fade when exposed to sun and rain) but the manufacturers also claim improved durability and stability among other improvements. ThermoWood® is being aimed at certain markets including internal uses such as in saunas, cladding, windows and decking.

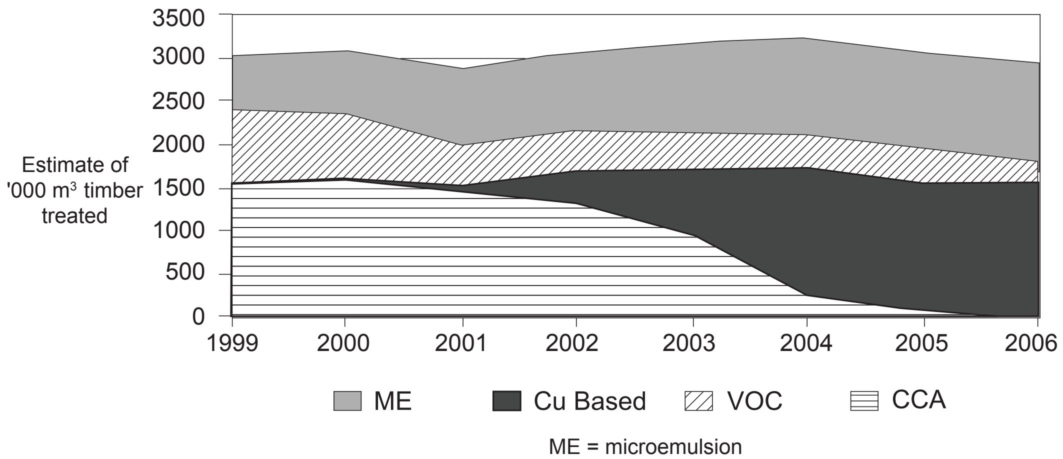

Figure 1 Wood treatment in the UK 1999–2006 (Ewbank 2004)

Another method of ensuring the durability of otherwise non-durable species is to impregnate the wood with chemicals that are not biocides but which react with the wood substance to render it more durable and improve properties such as dimensional stability. Examples are acetylation, which involves pressure impregnating wood with acetic anhydride, produced from acetic acid, and furfurylation using furfurylalcohol. A modified wood using the acetylation process has been launched on the market in Europe under the brand name Accoya®.

An advantage of these techniques is that cheap and plentiful, but not naturally durable species can be used without using traditional chemical preservatives. Other advantages are that the protection extends right through the wood, unlike preservative treatment which often penetrates to a limited depth and therefore requires the addition of site-applied preservative to cut ends, notches, holes, etc. The wood also becomes more resistant to moisture absorption, resulting in less moisture movement than is typical of untreated wood. When modified wood comes to the end of its service life it may be that it may be disposed of in the same way as untreated timber and this may become a significant advantage as disposal routes are closed off or become more costly.

The industry faces a challenge in characterising modified wood so that informed decisions can be taken by specifiers and users. How for example can the durability of modified wood be compared with that of naturally-durable timber or preservative-treated timber? How can its service life be predicted? What is the cost compared with preservative-treated timber? Are there environmental questions such as the CO_2 'footprint' of heat treatment compared with preservative treatment? The UK Wood Protection Association has established a task group to help it develop guidance on these issues for specifiers and users of modified wood.

Modified wood then already plays a part in the overall market for wood where improved properties are required. Europe seems to be the hub of this activity but we can expect it to make a global impact in the future.

Wood at the end of its service life

The management of wood at the end of its service life is becoming a major issue for the timber and timber using industries. Currently high on the agenda in Europe and North America due to regulatory controls and environmental pressure groups, this could be a significant global trend affecting our industry. The volume of, for example, CCA-treated timber requiring disposal in coming years is very high (Cooper 2004)

In Europe CCA- and creosote-treated timber for disposal is classified as hazardous waste and can't be disposed of other than at landfill sites or incinerators licensed to accept hazardous waste. For the time being there are very few such facilities. Strategies are needed to help society manage such wastes so as not to risk losing the benefits of treated timber due to fear of insurmountable problems at the end of its service life.

The UK Wood Protection Association is developing a Code of Practice with re-use and recycling as the preferred options for treated wood at the end of its service life. Disposal as a waste should be the last option but when disposal is required the industry needs appropriate processes in place to manage the material in an environmentally responsible way.

Where treated wood is used in large individual units (e.g. poles) or in discrete structures (e.g. fences) it can be easily identified and segregated from other wastes. Since these are typically Use Class 4 (in ground or fresh water) the preservative used will probably be easily determined. Treated timber from these uses can then be re-used, recycled or finally disposed of by a number of routes including burning for energy production.

However, when treated timber is used in construction of buildings, re-use and recycling may be more difficult. Following demolition of a building, treated timber may be mixed with untreated timber and other construction waste. The range of preservatives that could have been used is much wider and identification of treatment potentially more difficult.

Under these circumstances some form of labelling would facilitate disposal. However, since treated wood may be cut to size on site or during its service life and considering we are looking at service lives in excess of 60 years, perhaps in wet conditions suitable labelling is clearly not just a matter of stapling a label onto the end of each piece of wood. The industry is considering the best way forward but a properly thought-out strategy is needed and not 'quick fix' answers.

In Europe many industries are being forced by regulation to take responsibility for their products at the end of their service life—examples are vehicle and computer manufacturers. Is this a model for our industry? Such an approach has been tried in Finland but without success.

CONCLUSIONS

The timber preservation industry faces challenges on a scale never seen before. These include adaptation to new approaches to service life prediction and standardisation, ensuring a level playing field for comparisons with modified wood and other competing technologies, managing a transition to regulation at a new level and a higher cost and finally in ensuring strategies for disposal of treated wood at the end of its service life that are acceptable to regulators and society.

The industry has an obligation to manage these issues successfully so that the benefits of treatment are not lost. These benefits include long life for lower durability timbers in situations where they would otherwise have an unacceptably short life; the prevention of fungal decay and insect attack keeping carbon locked up in the timber and not contributing to global warming; preserving confidence in the performance of timber and reducing the risk of timber being replaced by less sustainable materials like steel, concrete and plastic.

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