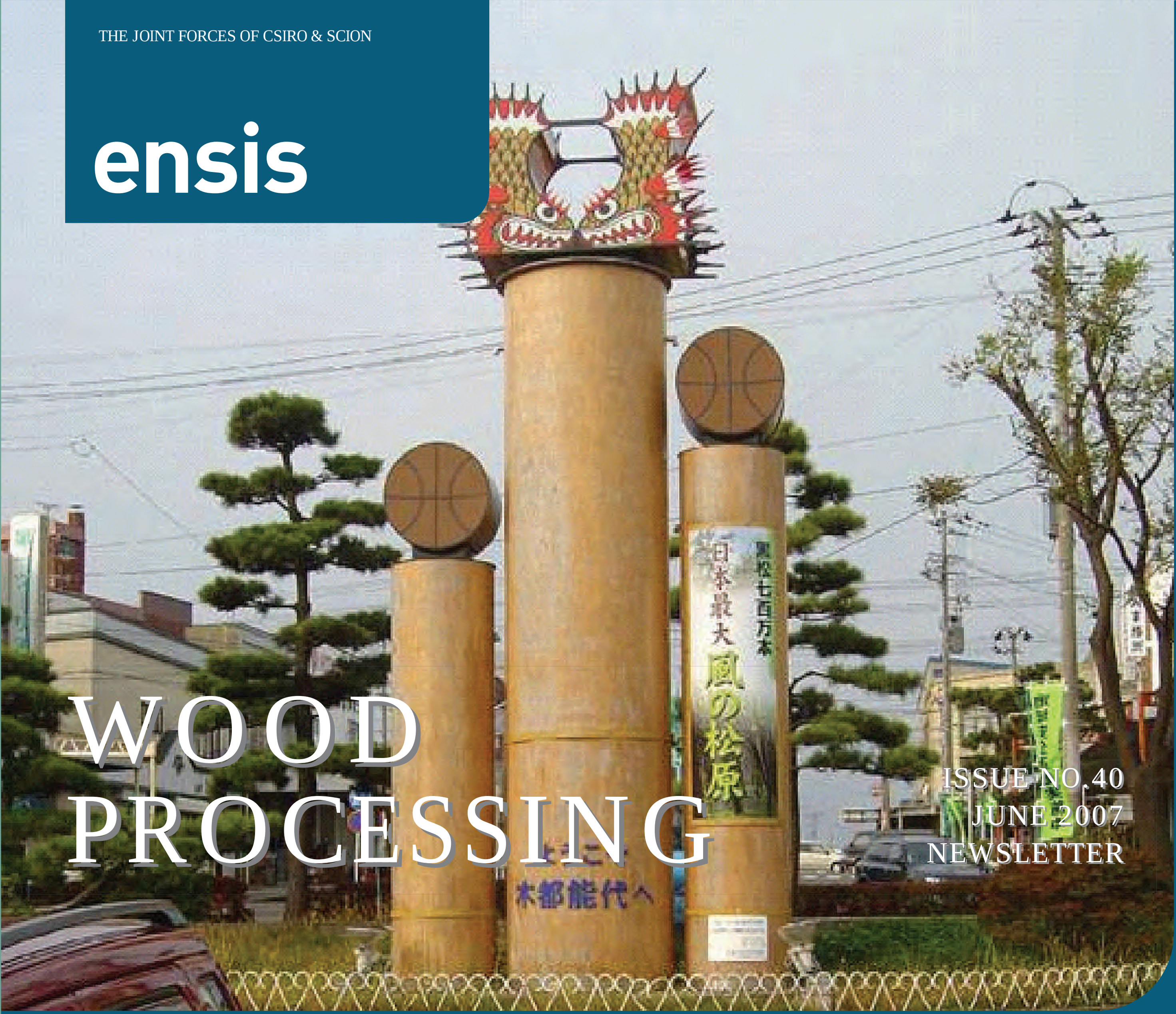
THE JOINT FORCES OF CSIRO & SCION

ensis



WOOD PROCESSING

ISSUE NO.40
JUNE 2007
NEWSLETTER

CYLINDRICAL LVL
- JAPAN

RESINOUS RADIATA

BIOENERGY

MAINTAINING
KILN SETTINGS

ISSN 0113-6224

CSIRO
SCION
THE JOINT FORCES OF CSIRO & SCION

Sawmilling

Issue No. 40 June 2007

IUFRO ALL DIVISION 5 (WOOD PRODUCTS) CONFERENCE

Dave Cown
Co-ordinator, IUFRO Division 5 (Forest Products)

The 2007 IUFRO Forests Products Conference "Forest Products and Environment — A Productive Symbiosis" will be held at the Taipei Grand Hotel, Taiwan, 29 October to 2 November 2007. It is planned to bring together researchers in forest products and related fields from around the world to discuss current issues in supplying the rapidly increasing demands for forest products of all kinds, while maintaining forest resources for the full array of social, economic, and environmental benefits. So far, over 250 scientists from around 30 countries have expressed interest in presenting their research at the conference.

The International Conference Committee has selected guest speakers from around the world (including the host country) to give keynote presentations on several topics. The bulk of the meeting will consist of up to 60 scientific sessions across 13 forest products disciplines, including fundamental aspects of wood formation and quality, energy and chemicals from forest biomass, wood processing, forest products marketing, non-wood forest products, and forest products education. Poster sessions will be presented differently from in the past — all posters will be exhibited during 3 days, and short verbal summaries will be presented at the end of each technical session. A range of evening events has been arranged to allow for all attendees and accompanying persons to socialise.

To support more scientists for the conference, a Scientist Assistance Programme (SAP) has been organised to receive and distribute funds generously donated by various organisations. So far, contributions have been received from USDA Forest Service (USFS), the Asia Pacific Association of Forestry Research Institutions (APAFRI), the Society of Wood Science and Technology (SWST), Chinese Academy of Forestry (CAF), and the Local Organising Committee (LOC) to support more than 25 scientists, mainly from the developing countries. Korea Forest Research Institute (KFRI) through the effort of Dr Don K. Lee, the current President of IUFRO, has donated a significant sum of money to support young scientists in joining the conference — it is one of the IUFRO's new goals to encourage more young people to participate in international events such as this. IUFRO is still looking for donors to support more scientists as the conference preparations proceed. This year SAP will support 10 students from International Forestry Students' Association (IFSA) to come to the conference. The students will assist during the conference while getting the opportunity to mingle with established scientists and present their own studies.

The IUFRO All Division 5 Conference is held every 5 years in a different location. This time, the Conference Organising Committee (COC) anticipates having 300 to 500 scientists from all over the world to attend this important international event. The organisers anticipate that because of the convenient location of Taiwan, many more scientists from Asian counties will participate than in the past.

For those who are interested, the deadline for the receipt of oral presentation abstracts is 17 May 2007 and the deadline for posters is 17 July. Online registration forms and other conference-related information are available on the conference website at http://www.alldiv5iufro2007.org.tw/index.htm. Registration can also be made through email or fax and the registration form can be downloaded from the website. For any questions about the conference, please contact the conference secretariat by email: iufro2007@gmail.com.

We are looking forward to a large turn out in Taipei for the Conference in October 2007.

NOVEL PRODUCT FROM JAPAN – CYLINDRICAL LVLS

Dave Cown

Last year, during attendance at a workshop in Japan, I came across what appeared to be a very novel and innovative product (cylindrical LVL).

The Japanese land mass is heavily forested (66%), but much of this is in the mountains and now protected. However, there is a huge number of private plantations — mostly just a few hectares in extent. Most of the plantations are Sugi (*Cryptomeria japonica*) and slow growing (rotations from 40 to 80 years depending on genotype and region). There is a big social issue in that forest workers are scarce, old, and poorly paid, and best management of Sugi requires high stocking, and regular thinning and pruning to maintain the growth and value. While Sugi is traditionally a very important wood for the Japanese, the large dimensions available in the past are now very scarce and highly prized. The available material is largely from the plantations which are widespread but of comparatively poor quality because of the age-class distribution and the lack of silvicultural management.

Mature Sugi in protected forest

Most universities and wood research institutes have significant programmes aimed at finding profitable uses for this material. One such activity has been commercialised in the north-east corner of the main island, Honshu, at the small town of Noshiro. The new product was developed locally at the Akita Wood Research Institute — cylindrical LVL. Veneer from low-quality stems can be used to create cylindrical products of various dimensions, for application in high-value uses such as the replacement of historical temple poles. In the manufacturing process, the veneer is peeled using a rotary lathe and cut into 150-mm strips which are then sewn together to produce an endless strip. A machine was developed to helically wind the narrow veneer strips around a metal spindle in alternating directions, and glue them with RF or isocyanate glue. This “mimics” the structure of wood by alternating the layers by 10° from the longitudinal, to give the structure additional strength. In this way, hollow sections of up to 1.5-m diameter can be created. For appearance situations, an outer layer of clear veneer can be applied to satisfy the Japanese preference for high-quality products. A “cut and re-build” process, whereby the tubes can be separated into two halves, allows placement around existing structures such as traditional temple posts or even rectangular wooden framing. For structural uses, several methods of end jointing were also developed to meet Japanese standards.

The research has resulted in the commercial ability to produce large wooden columns with crack-free surfaces. The design allows large section members to be produced using a minimum of (low grade?) wood. The outer layer can be clear veneer to simulate high quality “old growth”.

On the face of it, this was an innovative research approach to solve a perceived need, but I understood the manufacturing company was experiencing some difficulty in developing a consistent market for the product.

Mature Sugi disc and cylindrical LVL

Wood Quality

Issue No. 40 June 2007

RESINOUS RADIATA: UNDERSTANDING RESIN STREAKS AND WHY DOES TIMBER BLEED RESIN

Adya Singh, Bernard Dawson, and John Turner

As part of our FoRST-funded wood processing research, we have collaborated with the NZ Pine Manufacturers' Association, to investigate the mechanism of resin bleeding from radiata pine timber in internal and external service situations. The over-arching theme is that development of "maintenance free" claddings is necessary to attract increased market interest in wood use. Wood as a sustainable material has very clear life cycle analysis benefits over competitive products based on steel, concrete, polystyrene, and metal. The market place has expressed preference over recent decades for performance without the need for maintenance of materials. The future is likely to see an increased uptake of sustainable materials as global warming and carbon sinks become mainstream.

Our working subgroup asked what causes resin bleeding? Anecdotal commentary holds that resin bleeding in primed treated FJ material is due to high light organic solvent levels. But there is no definite information on whether this is the actual cause. This work looks at the influence of the several factors. In the first part of the project, wood factors including resin defect, kiln-drying temperature, presence of solvent, and radiant heating were worked into a factorial design. Secondly, and following the results of the first part, mitigation treatments will be considered.

Resinous timber

The presence of excessive resin is a serious defect for radiata pine timber, causing problems all along the processing chain from sawing and drying through to finishing with protective coatings. It is not uncommon to find incrustations of resinous materials on the surfaces of radiata pine wood products after years in service, particularly in outdoor situations. Emergence of resinous postules through protective coatings applied to weatherboards and deck panels is not only unsightly but can also create points in the coating where water can readily enter into the underlying wood surface, accelerating coating failure and in time also wood deterioration due to microbial colonisation and attack.

Where the resin content of radiata pine is excessively high, the presence of resin in sawn timbers is readily observable on both longitudinal and cross cut faces (Fig. 1, 2). In cross-cut views of resinous radiata pine, latewood bands are more sharply defined than in non-resinous material (radiata pine with normal

Figure 1.

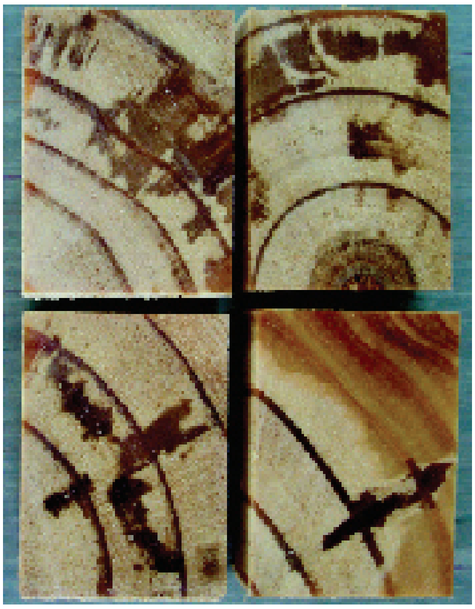


Figure 2.

resin content) (Fig. 1, 2). They appear brownish in colour, and the intensity is apparently correlated to the amount of resin associated with the latewood bands. Resin-rich regions can also be readily detected in earlywood regions as brown-coloured streaks on longitudinal faces (Fig. 1) and irregular patches on cross-cut faces (Fig. 2). The resin streaks/patches are associated with latewood bands, occasionally spreading across two or more (Fig. 2).

It is known that excessive resin production poses a real problem for the use of radiata pine, particularly in external applications where the timber can continue to bleed resin for years. Resin bleed in internal service situations is also disfiguring and undesirable. However, studies have been limited largely to visual observations and comparative assessments of the populations of resin canals, the primary source of resin production in standing trees. Resin canals in radiata pine wood are associated mainly with latewood bands, and thus are present in discrete regions. So, resinous streaks are somewhat of a mystery, and we need to understand what they are and how they form. Recently we examined resinous radiata pine timber from various sources with a range of methods including photography using a digital camera, light microscopy of microtomed sections, and NMR imaging. Light microscopic observations, which proved valuable in understanding the cellular basis of resin streaks/patches, are illustrated and discussed in this note. NMR studies are not yet complete and will be presented in a subsequent report.

As can be seen in Fig. 3, all rays present within the resin streaks/patches are filled with resin, and resin is also present in many axial tracheids, filling them partially or completely. Furthermore, resin distribution within the streaks/patches is not entirely uniform at the tissue level, with the resin filling greater numbers of axial tracheids in some parts than others (Fig. 3, 4). It is also apparent that cells appearing empty of resin in low magnification images in fact contain some resin when viewed at a high magnification (Fig. 4).

Resin streak formation – a dynamic process

In order to understand how resin streaks form, it is necessary to first grasp some anatomical concepts involving wood structural elements such as earlywood, latewood, rays, resin canals, and how these elements together constitute a three-dimensional network for the movement of liquids, including resin, up and down and horizontally within the tree.

Based on the illustrations presented and the macroscopic and microscopic observations made, we propose that, in resinous radiata pine wood, resin diffuses into rays and axial tracheids from resin

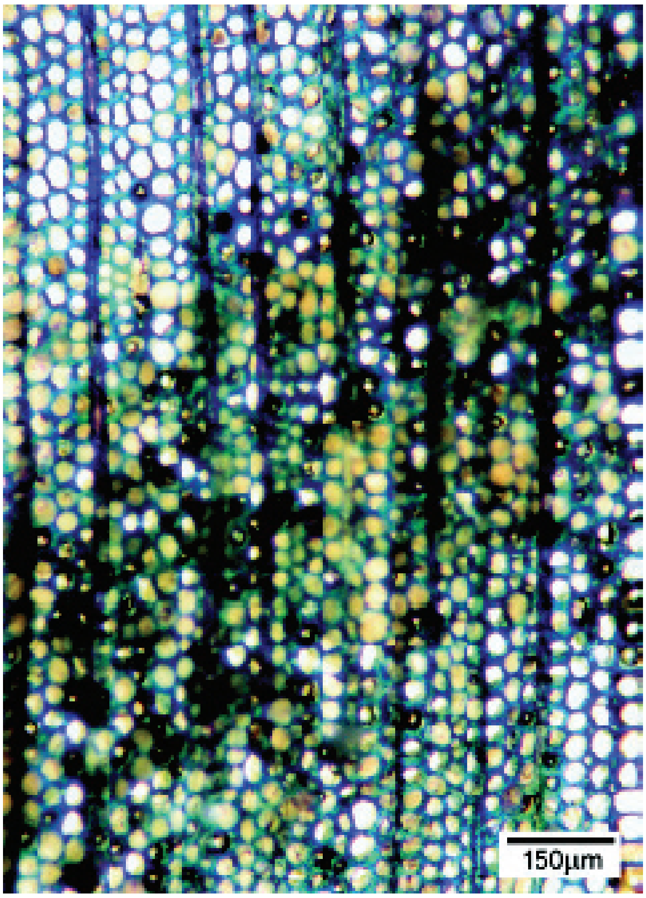


Figure 3.

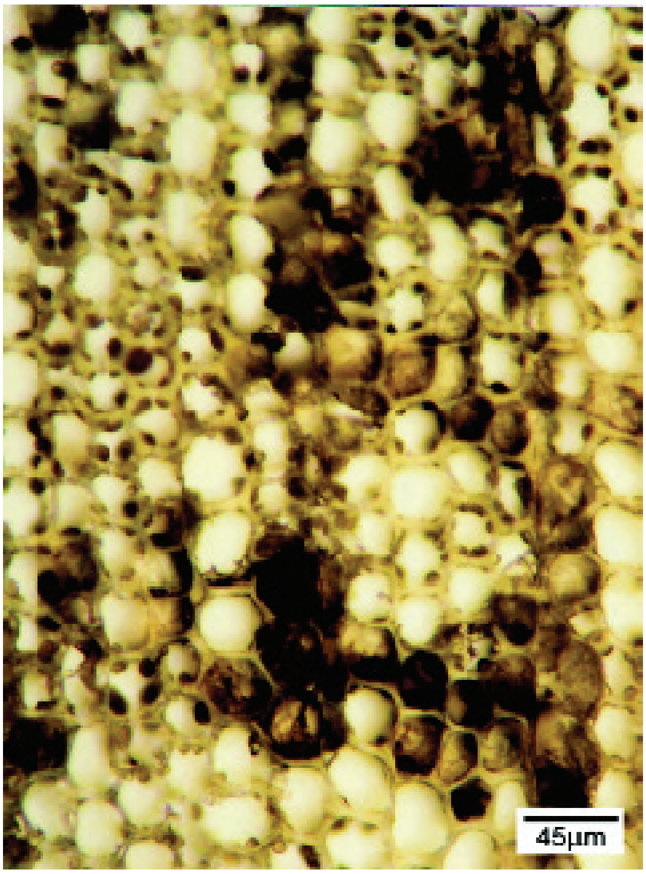
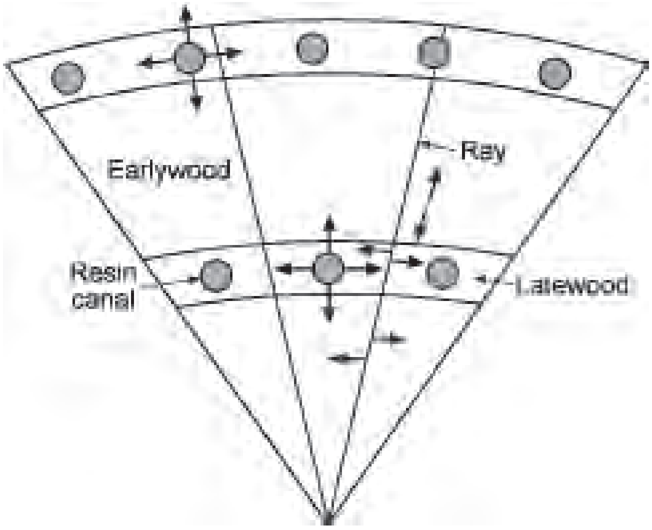


Figure 4.

canals, the site of resin production. While the bulk of resin flows into axial tracheids from resin canals, resin can also flow into axial tracheids via rays (diagram), as in radiata pine wood each tracheid is in contact with a ray at least at one point along its length. Thus instead of being confined to resin canals present in latewood bands, as is the case in normal wood, in resinous radiata pine wood large masses of resin-filled tissues become resin impregnated as a result of such resin movement. Such regions would appear as resin streaks and resin patches.

Resin bleeding

We have described how features such as resin streaks and resinous latewood bands form, but once the trees are milled and processed, and weatherboards (for example) have been made and used in a building, we need to know how the process of how resin bleed occurs. The question to be answered now is how does resin exude or bleed from such resin-rich regions when the boards are in service. We are still continuing work in this area, trying to understand how the ups and downs of temperature, within days and seasons, results in mobility of resin and unseemly looking resin bleed. Pressures force resin out of the timber and coatings are unable to quell this.



Resin flow pathways (arrows) in wood. Not drawn to scale.

A NOVEL APPROACH TO PROBING WOOD-ADHESIVE INTERFACE USING CORRELATIVE LIGHT, CONFOCAL AND SCANNING ELECTRON MICROSCOPY

Adya Singh, Bernard Dawson, Catherine Rickard, and Jacqueline Bond

Microscopic techniques which provide complementary information, such as correlated light, confocal, and electron microscopy, have been very useful in our work related to characterisation of wood products at the cellular and tissue levels and assessment of their in-service performance. The work reported in this article is part of the investigation aimed at understanding interfacial interactions between the components of biomaterials-based products. In a previous issue of the *Wood Processing Newsletter* (No. 38, June 2006) we described the interactions that take place between wood tissues and a protective coating applied to band-sawn radiata pine plywood. The work described here is based on the development and use of a novel correlated microscopy technique to probe wood-adhesive interface in a radiata pine plywood.

A reminder of the structure of plywood is relevant as the illustrations are micrographs of sections taken through two successive plies glued with an adhesive. Plywood is produced by gluing together a number of layers (plies) of wood with the grain direction in successive plies at right angles to each other. Thus in the cross-sections through two successive plies, the grain in one ply is cut transversely and in the other longitudinally (*see* Fig. 1).The grain pattern in plywood is different from that of another popular manufacturing product produced in New Zealand — laminated veneer lumber (LVL) — in which the grains in the successive multiple layers have the same alignment.

Adhesives have been used for bonding wood panels and particles for a long time. Commercially, adhesives have been used to produce a range of wood products of high value, such as laminated beams, plywood, and strandboard, chipboard, and particleboard. The performance of adhesives depends on many factors, and the physical and chemical characteristics of both wood surfaces and adhesives determine the quality of bonding. Wood-adhesive interactions that take place

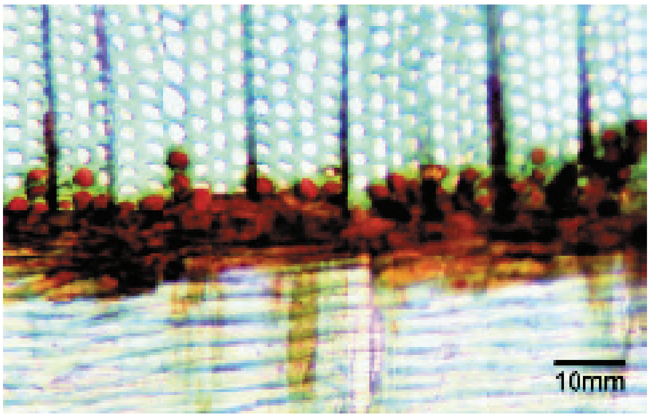


Figure 1. Light micrograph showing adhesive penetration into rays from the adhesive line (arrow). The wood-adhesive interface is not well defined. Bar = 60 µm.

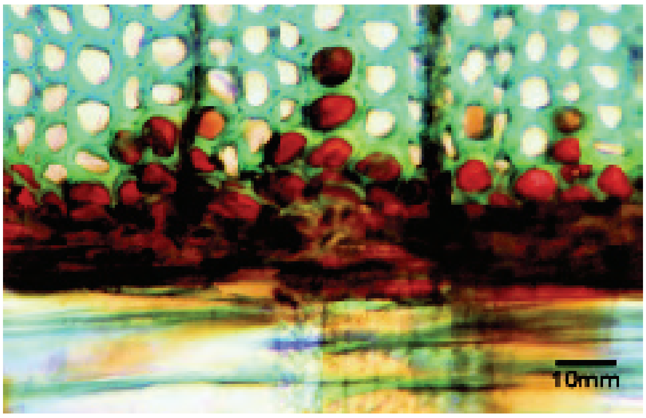


Figure 2. Light micrograph showing enlarged view of an area of the adhesive line in Figure 1. The adhesive penetration into tracheids is up to several cells deep from the adhesive line. Bar = 35 µm.

at the interface, i.e., the place of contact of adhesive with wood, involve chemical bonding as well as physical factors such as mechanical interlocking (entanglement) of adhesive into wood tissues. Collectively, these interactions determine the bond strength.

Techniques for characterising wood-adhesive interface are continually evolving, and we have developed a novel microscopy approach to probe the wood-adhesive interface in order to more clearly understand the physical wood-adhesive interactions in a commercial plywood product bonded with a phenol-formaldehyde adhesive. The technique involves correlative microscopy of 90-µm thick, microtome-cut sections through the wood-adhesive interface, after appropriate treatments of sections. The same sections are sequentially examined by light microscopy (LM), confocal laser scanning microscopy (CLSM), and then field-emission scanning electron microscopy (FE-SEM). This approach is a new technical development for wood-adhesive research and has provided valuable new information, particularly on the intricate adhesive penetration pathways within the surface tissues of the bonded wood plies, resolved in sharply focused, high-resolution images.

The correlative microscopy approach involves development of specific staining and imaging techniques, which enable the same sections to be examined sequentially by LM, CLSM, and FE-SEM to gather information that was not obtainable using any one of these microscopies alone. The sections cut through the wood-adhesive interface using a sliding microtome at a thickness of 90 µm are stained with aqueous toluidine blue stain prior to examination with LM. This stain, which imparts bluish-green colour to lignified wood cell walls, is effective in clearly differentiating wood cell walls from the phenol-formaldehyde adhesive, which keeps its original brownish colour. LM is useful in following ways:

(1) It provides evidence that the adhesive has penetrated into the lumens of rays and also of axial tracheids up to four cells deep from the adhesive line (Fig. 1 and 2).

(2) LM indicates that the adhesive may also have penetrated into the cell walls, particularly those of tracheids in contact with and near the adhesive line, as the cell walls in these tissue regions are orangish and not the bluish-green colour typical of the cell walls of tissues distant from the adhesive line and out of direct reach of the adhesive.

(3) LM enables a large number of sections to be examined in a relatively short time, and thus large segments of the wood-adhesive interface. However, the inability of LM to bring the distant wood tissues into the same focal plane as the wood-adhesive interface is a severe limitation of this type of microscopy.

After examining and photographing with LM, the same sections were examined with CLSM under fluorescence mode at excitation wavelengths of 488 and 568 nm and emission wavelengths of 530 and 600 nm. The combination of toluidine-blue staining of sections and using suitable operating conditions of CLSM enabled the adhesive to be sharply differentiated from wood cell walls based on bright contrasting colours of the adhesive (greenish) and wood cell walls (reddish). It was also possible to visualise adhesive penetration into wood tissues more clearly than with LM, as the unique capabilities of CLSM in optical sectioning through an object (laser-aided slicing through the microtome-cut section in our work) and then obtaining a composite image of sequential sections through a considerable depth enabled large tissue areas to be brought in the same focal plane as the adhesive line, which was not possible with LM. Furthermore, a combination of superior colour differentiation between the adhesive (greenish) and wood cell walls (reddish) and image sharpness made it possible to visualise the wood-adhesive interface more clearly than was possible with LM, and this greatly enhanced the value of the information obtainable on wood-adhesive interactions. In Fig. 3, the entire view in field is in the same focal plane and thus sharply defined, enabling the intricate pathways of adhesive penetration into wood tissues of the plies flanking the adhesive line to be clearly resolved. The adhesive has penetrated into the lumens of ray tissues and axial tracheids, as well as into cracks present within the ply face exposed to the adhesive line that are likely to have formed during peeling of veneers from logs. The light green to orangish colour (and not reddish) of the surface tissues embedded in the adhesive suggests that the adhesive has also penetrated wood cell walls. Penetration of the adhesive into cell walls is more obvious in Fig. 4, a higher magnification view of a wood-adhesive region in Fig. 3. Comparison of tracheids which are farthest from the adhesive line, where cell walls are reddish and the middle lamella shows greatest brightness and is thus clearly distinguishable from the secondary wall, with those nearest the adhesive line, where cell walls are light green, suggests that the adhesive may have completely penetrated cell walls in addition to penetrating cell lumens. In the transition zone, cell walls appear to be only partly impregnated with the adhesive, as the patchiness of cell wall colours would suggest. Figure 4 also displays an intricate pattern of adhesive distribution within the tissues nearest the adhesive line, which appear to have been damaged (probably during veneer peeling) with some cells severely compressed and cracks within cell walls present. The adhesive has penetrated all accessible spaces and is present in cell lumens, cell wall cracks, and cell walls, creating a wood-adhesive polymer composite in the wood-adhesive interface region.

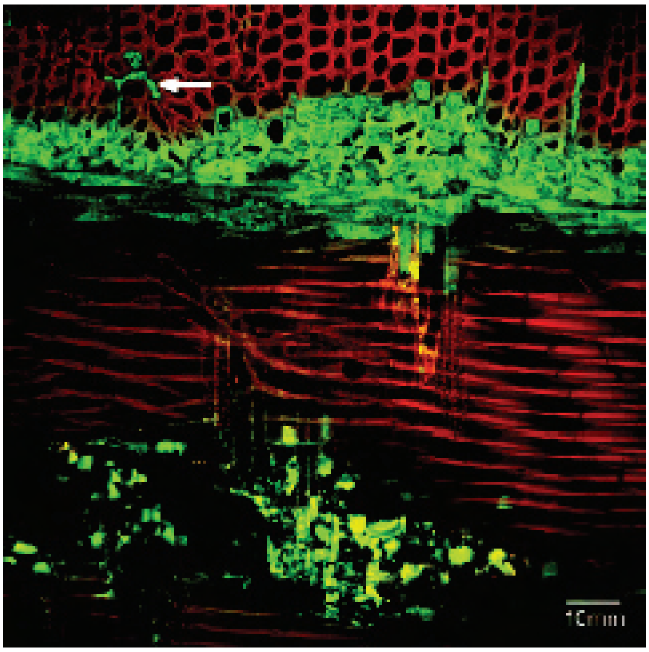


Figure 3. Confocal micrograph of the adhesive line (greenish) between two plies, showing deep penetration of adhesive into rays. (Greater brightness of rays in the lower ply is due probably to reaction of the adhesive with the extractives present in the rays). The adhesive has penetrated into tracheids in the surface layers of the glued plies all along the adhesive line as well as into cracks within tissues (arrow). Bar = 50 μm.

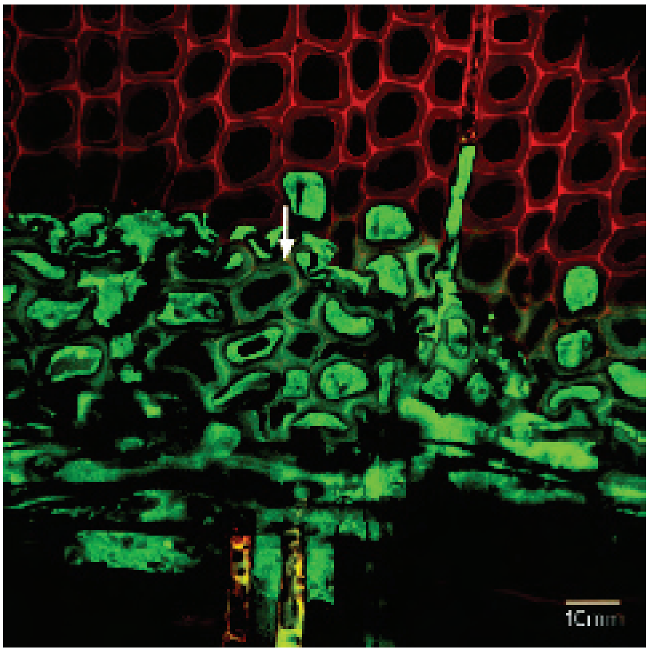


Figure 4. Confocal micrograph showing enlarged view of an area of the adhesive line in Fig. 3. In addition to filling the lumens and the damaged tissue regions the adhesive appears to have penetrated cell walls, particularly in the surface tissue layers of the upper ply (arrow pointing to light green coloured cell walls). Bar = 25 μm.

SEM added another important dimension to visualising adhesive penetration into wood tissues. High resolution imaging with the FE-SEM used in combination with backscattered electron imaging (BEI) provided remarkable definition of the wood-adhesive interface, made possible by the high resolution capability of this instrument and enhancement of differentiation between the adhesive and wood cell walls based on a special technique that we developed to increase the contrast of the adhesive relative to cell walls. The technique involved treating the toluidine-blue-stained sections (which we had examined with LM and subsequently with CLSM) with osmium tetroxide prior to examination with the FE-SEM in combination with BEI. The contrast differentiation between two or more components in a composite material under BEI is based on atomic number differences. Higher atomic number components appear brighter than lower atomic number components under BEI because of greater yield of backscattered electrons. Thus differentiation between the components differing in their atomic number is based on brightness intensities. As osmium is a high atomic number metal, it enhances the emission of backscattered electrons from the materials with which it can physically or chemically react, such as the phenol-formaldehyde adhesive, thus increasing their brightness under SEM-BEI viewing.

The micrograph in Fig. 5, which was taken with the FE-SEM in the BEI mode, illustrates the value that BEI adds to imaging osmium tetroxide reacted phenol-formaldehyde adhesive. In comparison to rather poor differentiation between wood cell walls and the adhesive achieved when imaged with the FE-SEM in the secondary electron imaging (SEI) mode, which is the standard imaging mode in the SEM work (Fig. 6), excellent differentiation between wood cell walls and the adhesive was achieved when the same sections were examined in the BEI mode (Fig. 5). This enabled adhesive distribution within wood tissues to be clearly visualised, as shown in Fig. 5 and 7. In Fig. 5, a low magnification FE-SEM-BEI image, the pathway of adhesive penetration into the damaged surface tissues of a ply is clearly visible. The adhesive is present within the lumens of tracheids and also in the damaged tissue regions containing cracks. The rather intricate pattern of adhesive distribution within surface wood tissues is observable in the high-resolution image in Fig. 7, which is a high-magnification view of a region of the wood-adhesive interface in Fig. 5, The presence of adhesive is detectable even in very small dimension cell wall cracks, which LM and CLSM could not resolve.

In conclusion, the unique imaging technology we developed involving sequential viewing of the same sections taken through wood-adhesive interface, by correlative LM, CLSM, and FE-SEM-BEI microscopy has provided new fundamental information on wood-adhesive interaction, which forms the basis for understanding why mechanical interlocking of adhesive into wood tissues is considered important in adhesive performance. Effective interlocking of wood tissues by an adhesive, involving adhesive penetration into all accessible micro- and nano-pores along the adhesive line, is even more crucial for optimal adhesive performance where mechanically weakened wood surfaces, such as in wood plies produced commercially by mechanical peeling of logs, have to be stabilised and strengthened.

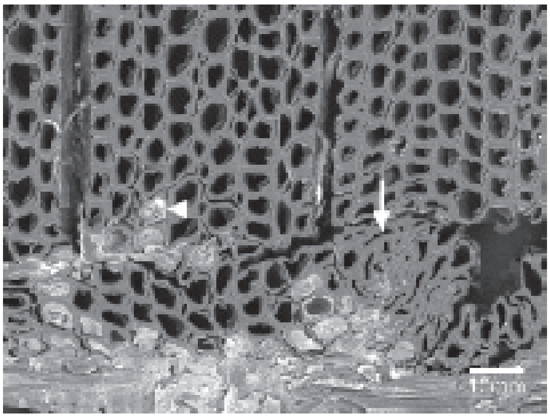


Figure 5. FE-SEM micrograph of the same region of the section as in Fig. 6 taken in backscattered electron imaging (BEI) mode. The adhesive is well differentiated from wood cell walls because of its much greater brightness than cell walls. The adhesive has penetrated a few cells deep into axial tracheids, but more deeply into a cracked region (arrowhead). The adhesive is excluded from a surface tissue region containing highly compressed tracheids (arrow). Bar = 50 µm.

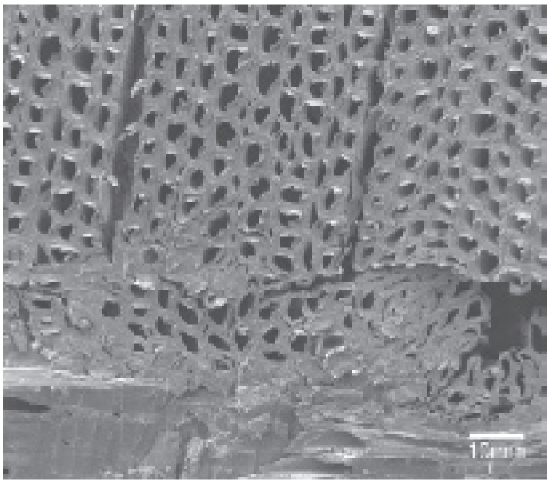


Figure 6. FE-SEM micrograph taken in secondary electron imaging (SEI) mode. The contrast of the adhesive is similar to that of wood cell walls and thus the adhesive is poorly differentiated from wood tissues. Bar = 50 µm.

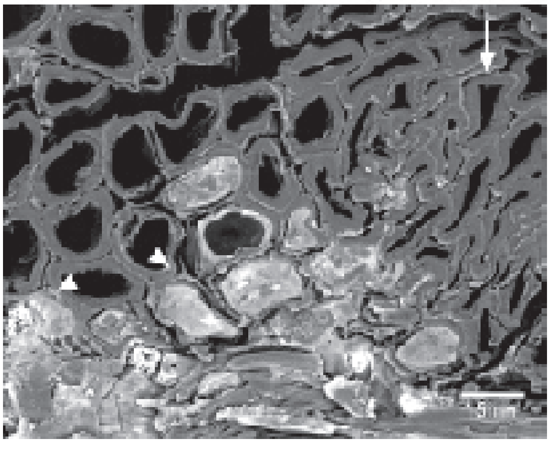


Figure 7. Higher magnification FE-SEM-BEI view of the compressed tissue region in Fig. 5. The adhesive has penetrated the lumens of uncompressed surface tracheids and cracks within damaged tissues, including very small-dimension cell wall cracks (arrowheads) but is largely excluded from the lumens of highly compressed tracheids (arrow). Bar = 20 µm.

Wood Drying

Issue No. 40 June 2007

Each issue we will delve into our files and give answers to frequently asked drying questions, trying to add to our general understanding of the technical issues

WHY DOES MY KILN STRUGGLE TO MAINTAIN DB SETTING WHEN I DROP THE WB SETTING? WHAT CAN I DO?

Steve Riley

Lowering the wet bulb (WB) setting means that you are lowering the humidity of the air in the kiln. This has two effects on the ability of the kiln to maintain its dry bulb (DB) setting:

(1) At lower humidity the air has the potential to gain more water, and so the evaporation rate of the water in the timber will increase. This requires more energy, for heat of evaporation, from the air that enters the stack and will thus tend to cool this air. Thus more heat is required from the heat exchanger.

(2) The actual lowering of the humidity of the air is achieved by venting moist air and inletting an equivalent amount of cool dry air. This extra cool dry air must be heated, again requiring more heat from the heat exchanger.

With the extra heat load, if the heat exchanger is not sized or the heat plant cannot deliver this heat rate, the DB temperature will not be maintained.

This typically happens after the preheat stage when the DB setting is reached with the vents shut. During this heat up period, little or no air is inlet, and drying rate is low. Thus DB setting is readily achieved. Then the drying step is commenced with a lower WB and immediately the DB cannot be maintained. Typically a 90/60 kiln after easily reaching 90/90 in about an hour, will spend the first few hours of its drying step with the heat valves at 100%, DB well below set point, and vents open. One could argue that drying is occurring so what's the problem. What is not often realised is:-

- With a zonal kiln with all valves at 100%, no evening between zones is occurring, during what is a fast drying period;
- More air is being sucked in than is necessary, meaning unnecessary heating cost;
- Since there is a large period of uncontrolled drying, drying time estimation is difficult.

Specifying a new Kiln

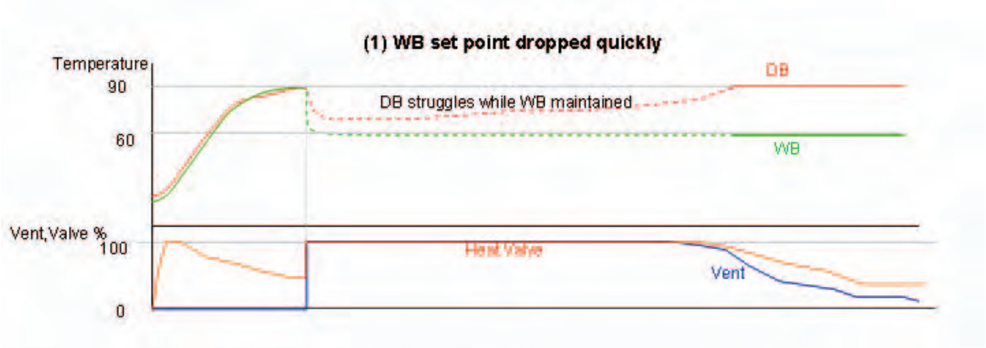
The issue of maintaining DB setting while the WB is decreased also pertains to the question of specifying a kiln for purchase.

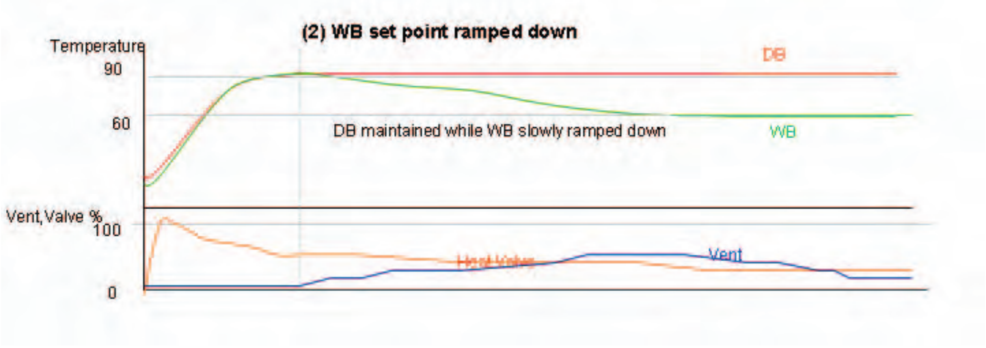
Traditionally when buying a new kiln, the buyer states the maximum temperature and its variation, the required airflow and its variation etc. … and a heat-up time. The heat-up time specification invariably states that the kiln with a specified charge size and composition will reach a desired DB temperature in a set time. From the information given here it can be seen that this can be very misleading. Your kiln may reach 90°C in 30 minutes with the vent shut, but soon as you begin drying and drop the WB set point to say 60°C you may spend many hours reaching 90/60. The ability to reach the DB temperature in a set time may bear little relation to drying ability. We have audited similar style kilns with similar airflows that have both reached DB set point in the same time, but have had quite different throughputs

We suggest that as well as specifying a DB heat-up time you also specify an ability to maintain a minimum set depression throughout the drying cycle.

What can I do?

1. Check to see if the inability to maintain DB setting is due to heat plant or under sizing of the heat exchanger. If heating fluid temperature or pressure is not maintained during this period of lowering the WB, then the heat plant is undersized. Apart from upgrading the heat plant your only option is to manage the starting of other chambers so that the overall heat load is evened out. If heating fluid temperature or pressure is OK, than the heat exchanger in the kiln is undersized for the task. This is not unusual as often kiln specifications are based on heat-up time to DB set point, not the ability to maintain a low WB early in the process.
2. The lower the WB temperature, the more air must be sucked into the kiln and heated. So, slowly dropping the WB set point to a lower setting will help. For example, if the initial part of the drying step is 90/60 but the kiln can only maintain 78/60, it would be better to have the kiln set to 90/72 — an 18°C WB depression is maintained but with less air drawn in, less heat is used to achieve the same result. Thus programming a downward WB ramp will help. See diagram below and compare heat valve and vent positions.

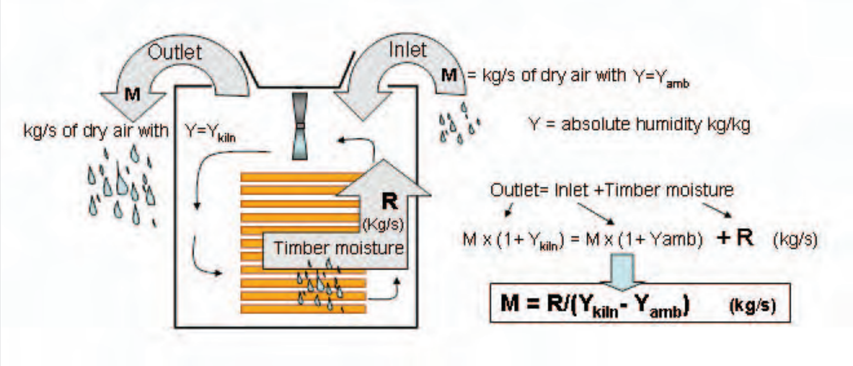




3. The danger is of course, that you will ramp down too slowly and inhibit drying unnecessarily. For this reason Dryspec™ has conditional ramps, which can automatically find the optimum ramp. Otherwise if your control system only allows fixed ramps, you will need to determine what ramp rate to enter. A suggestion is to look at the time for final WB depression to be achieved (DB finally returns to set point) and set the ramp rate of the WB to match this time.

What is a typical energy penalty of having an unreached DB with a low controlled WB *vs* a controlled DB and higher WB?

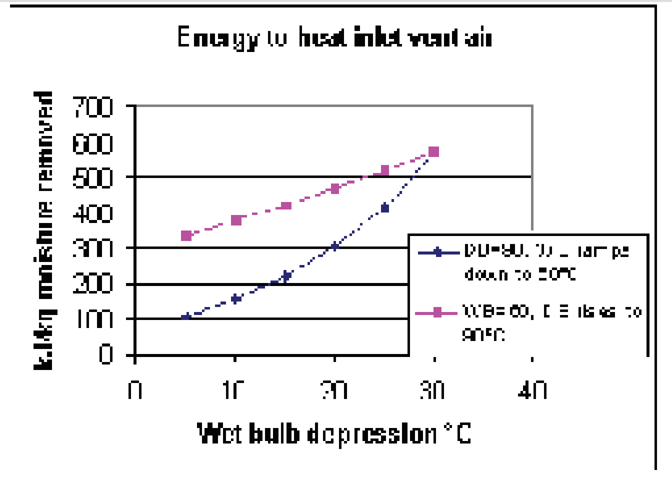
If one assumes that drying rate is proportional to WB depression (a reasonable assumption early in drying), the energy penalty between the two cases can be calculated by comparing the amount of heat required to heat up the air entering the kiln. Firstly we need to know the amount of air:-



Energy required depends on the amount of air (M) and the temperature to which it must be heated. Thus

$$\text{Energy rate} = R/(\,Y_{\text{kiln}} - Y_{\text{ambient}}\,) \times \text{Specific heat} \times (\,T_{\text{db}} - T_{\text{amb}}) \qquad (\text{kW})$$

This expression can be used to compare both strategies. This is done for the 90/60 case in the graph at right. This shows that there is about a 200 KJ penalty per kilogram of moisture removed between the high and the low WB strategies. In a 100 m^3 kiln trying to establish 90/60, the drying rate could be ~0.1 Kg/s. Thus the difference would be about 200 × 0.1 = 20 kW. While this may not be a lot of money lost (~$4/hr for ~6–10 hours) it is completely unnecessary and that energy could be going into drying, rather than heating up unnecessary air.



Environmental

Issue No. 40 June 2007

BIOENERGY TARGETS

Michael Jack

The Government has recently released the Draft New Zealand Energy Strategy (NZES) which contains the two goals of increasing national energy security and reducing greenhouse emissions from the burning of fossil fuels. Energy from renewable sources, including bioenergy from woody biomass, has been highlighted as an important part of achieving these goals. As part of developing a strategy for woody biomass, the Energy-Efficiency and Conservation Authority (EECA) contracted the Scion Bioenergy group and an energy consultancy, East Harbour Management, to determine renewable energy targets for the direct use of woody biomass in 2020 and 2030.

In 2001 the Government set the target of 30 Petajoules (PJ) of new renewable energy by 2012, and it was generally expected that bioenergy would provide half of this. However, our analysis strongly suggests that this broad brush approach over-simplifies the New Zealand bioenergy system and will, at best, have little effect on achieving the aims of the NZES and, at worst, reverse some of the gains made so far. Instead, our analysis has arrived at four specific targets that are likely to be the best method of both maintaining gains made so far and increasing the replacement of fossil fuel with biomass and therefore reducing greenhouse gas emissions. Each suggested target is described below, with a summary of the analysis that lead to the target.

1. The proportion of wood processors using biomass for heat production by installed capacity, or other renewable heat sources, is 90% by 2020 and 95% by 2030.

The wood processing industry is, and will continue to be, the major user of woody biomass for heat in New Zealand. We estimate that, presently, 94% of South Island sawmills and 74% of North Island sawmills use biomass as fuel (evaluated by installed heat production capacity). In addition, biomass makes up 82% of the fuel mix in the wood panel manufacturing industry and 90% in the pulp and paper industry. The above targets are therefore not a significant stretch beyond the present situation and are designed more to maintain current gains. This is important in light of other major trends discussed in more detail below. National exotic forest description (NEFD) predictions show a large increase in harvesting over the next 10 years (*see* Fig. 1); the effect of this on bioenergy utilisation depends on what proportion of this harvest is exported in log form, as the quantity of logs processed domestically is linked to the amount of residue available on-site for fuel use.

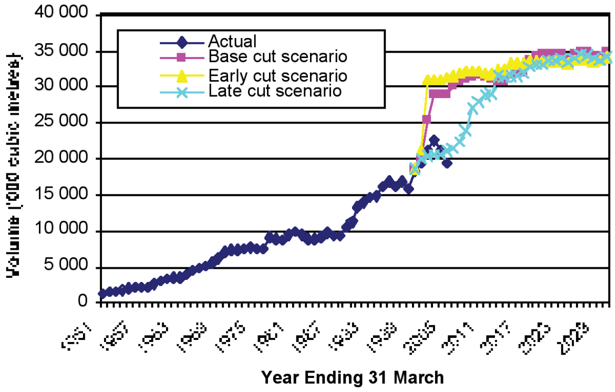


Figure 1. Forest harvesting scenarios

Therefore, numerical targets in amounts of primary energy are not useful in this case (i.e., PJ amounts) and we suggest that, for the above target, focusing on the proportion of biomass in th e fuel mix is more appropriate.

An important aspect of targets such as these is their measurability.

This first target is measured using the EECA heat plant database (the alternative — measuring consumed process residue — is extremely unreliable due to the lack of either measurement or recording of process residues used as fuel on processing sites). It is suggested that this database should be kept up to date and made more comprehensive. At present the high cost of residue disposal is a positive driver, and suggests that the waste management strategy is a vehicle for achieving this target. However, with the growth of the wood pellet market and other industry demands for high-quality process residue, this will not be sufficient to preserve biomass use in the wood processing industry.

2. The quantity of forest residues extracted is 7 PJ by 2020 and 9 PJ by 2030.

In addition to processing residue, there is a large biomass resource at forest landing sites. Presently 100 000 tonnes of forest residue (much of this from farm conversions) are being harvested for fuel at the Kinleith and Kawerau pulp and paper mills. To estimate additional uptake of this resource, a Geographic Information Systems model has been used to calculate the cost of delivered forest residue chip for use as an energy feedstock for each region in New Zealand. The cost includes all components of processing from collection, processing, and delivery tothe site for use.

An example cost curve for Rotorua is shown in Fig. 2. Eleven wood processing centres in the North Island and four in the South were chosen for the analysis of cost of supply. The names of neighbouring cities are shown in Table 1. These centres were chosen as the most likely places where forest residues will be taken up as a feedstock for fuel.

Table 1 (with its accompanying map) shows selected results from the analysis of the cost of supply for each of these centres out to 2020 and 2030. The supply cost in dollars per gigajoule is for supply of 0.5 PJ per site. The volume 0.5 PJ is the minimum volume for a viable harvesting operation, based on a hogger/residue processing machine needing around 50 000 tonnes per year for it to be a well utilised, economically viable operation. The difference in costs between the two years in each region is directly related to volume and distribution of available resource, which is in turn related to planting schemes.

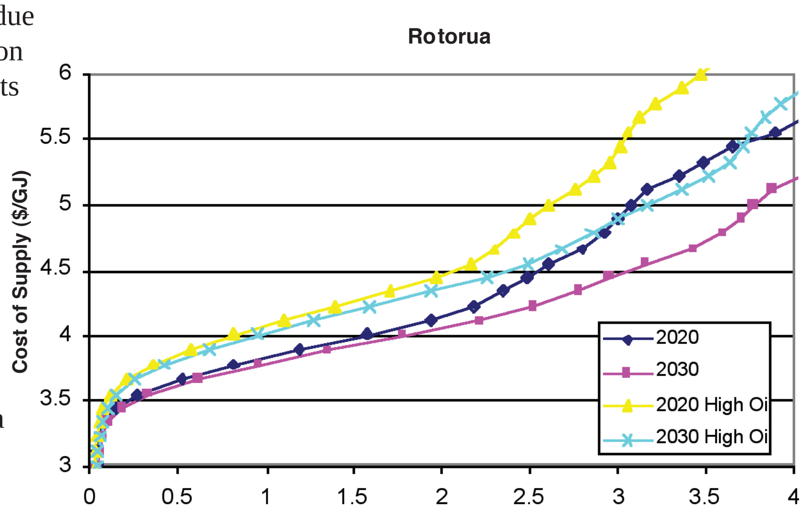
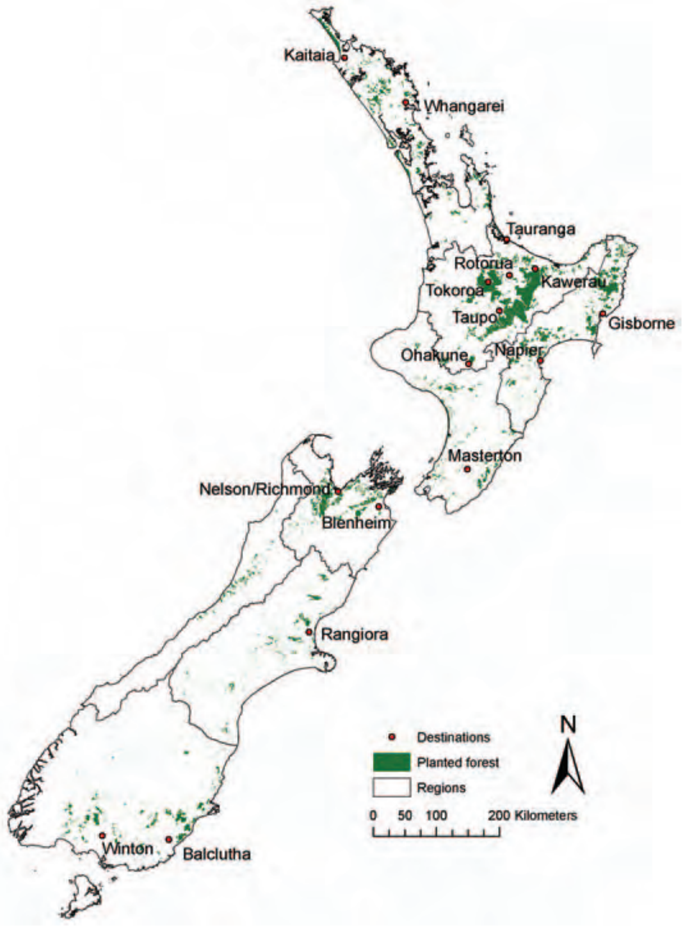


Figure 2. Supply costs of forest residues. The high oil lines correspond to MED's high oil price scenario.

Table 1. Supply costs of forest residue

	$/GJ (0.5 PJ pa operation)	
	2020	**2030**
Northland		
Kaitaia	4.7	4.9
Whangarei	4.3	4.6
CNI		
Rotorua	3.6	3.6
Taupo	3.7	3.4
Tokoroa	3.3	3.2
Kawerau	3.4	3.4
Tauranga	3.9	3.9
Ohakune	4.0	4.3
Hawke's Bay/ East Coast		
Gisborne	3.6	3.9
Napier	3.9	3.7
Southern North Island		
Masterton	3.9	4.3
Nelson/Malborough		
Nelson	3.7	4.2
Canterbury		
Rangiora	6.0	6.2
Otago and Southland		
Balclutha	4.2	4.7
Winton	4.9	5.3



By comparing the costs of extraction with fossil fuel price predictions we can determine quantities that are economically competitive.

Assuming a carbon tax of \$15/t CO_2 (or equivalent priced-based measure of CO_2 mitigation) above Ministry of Economic Development base case fuel price projections, we estimate that in 2020 it will be economically competitive with coal to harvest 7.2 PJ/year of residues from forests in the North Island to be used in industrial heat and in 2030, 6.6 PJ/year. The reduction in 2030 is due to reduced planting rates. This does not include residues from farm conversions which are assumed a short-term phenomenon. Without the tax, forest residue will not be economically competitive with coal, and quantities could be expected to remain insignificant. The significantly lower cost of coal in the South Island means that with this level of carbon tax, forest residue is still uncompetitive. The volume of forest residues economically competitive with coal will be reduced for higher oil prices largely because the delivered price of biomass is more sensitive to transportation costs than coal because of its lower energy content per unit volume.

Achieving the above targets will therefore require a carbon tax of at least \$15/t CO_2 or equivalent. It is suggested that the progress towards this target is monitored by requiring residue harvesting operations to report volumes recovered. The utilisation of this resource is likely to be in the forest industry, but could also be in other industrial sites with a large heat demand. Note, due to reduced planting rates residue recovery costs increased between 2020 and 2030, suggesting that sustaining these targets to 2030 and beyond requires a reversal of current deforestation trends.

3. An increase in the proportion of co-generation plants in the wood-processing industry (by installed capacity) of 10% by 2020 and 20% by 2030.

Cogeneration is the joint production of electricity and heat and is a highly efficient method of producing useful energy. Increasing the amount of cogeneration will result in an increase in the amount of mitigated CO_2 as the electricity generated will replace that from the national grid. Currently, cogeneration installed capacity is 22% of the total, mainly in the pulp and paper industry. This target can again be measured using the EECA heat plant database. Cogeneration requires a greater amount of fuel, and for sawmills is likely only if a mill has sufficient quantities of process residues on-site. Therefore, increasing the efficiency of the on-site heat process and the utilisation of biomass are necessary for the achievement of this target.

4. An increase in the utilisation of wood pellets of 3.6 PJ by 2020 and 4.5 PJ by 2030

Analysis shows that, following international trends, wood pellets are likely to be an increasingly important biomass fuel and because of their ease of use have the potential to replace fossil fuels in sectors without experience in using woody residue fuels — such as, the residential, commercial, and institutional sectors*****. This target is easily measured by having wood-pellet manufacturers record volumes of wood-pellet sales.

As the production of wood pellets requires high-grade residue, the upward trend in the utilisation of wood pellets is likely to create an increased additional demand for quality wood processing residues above current levels. Currently sawmills could be effectively self-sufficient in heat if they utilised all processing residues as fuel, and so any increased economic demand for these residues will reduce the waste disposal pressure on the wood processing industry and mean that mills are likely to sell some of their higher quality residues if a cheaper substitute fuel is available. This substitute fuel could be forest residues or coal, depending on the economics (or possibly geothermal energy, depending on location).

Therefore, the growth of the wood pellet (or liquid biofuels) industry could, perversely, result in mills switching to coal due to the chain of linkages of the residues. As a consequence of this it is possible that unless forest residues become economic to harvest in 2020 and 2030 the biomass usage in the sawmill industry will drop as quality process residue is diverted to production of wood pellets. Targets 1 and 2 are designed to act together to prevent the occurrence of this type of possibility. In particular, a carbon tax or similar incentive for forest residues needs to be in place to guarantee the use of biomass instead of coal.

This example emphasises the complexity and interconnectedness of the New Zealand bioenergy "system". Examples of the effect of the presence or absence of a carbon tax on this bioenergy system for a particular scenario in our analysis are shown in Fig. 3.

---

* Note that higher quality chip from forest residue is also likely to have applications in the industrial and commercial sectors if economic to recover. This is accounted for by target 2.

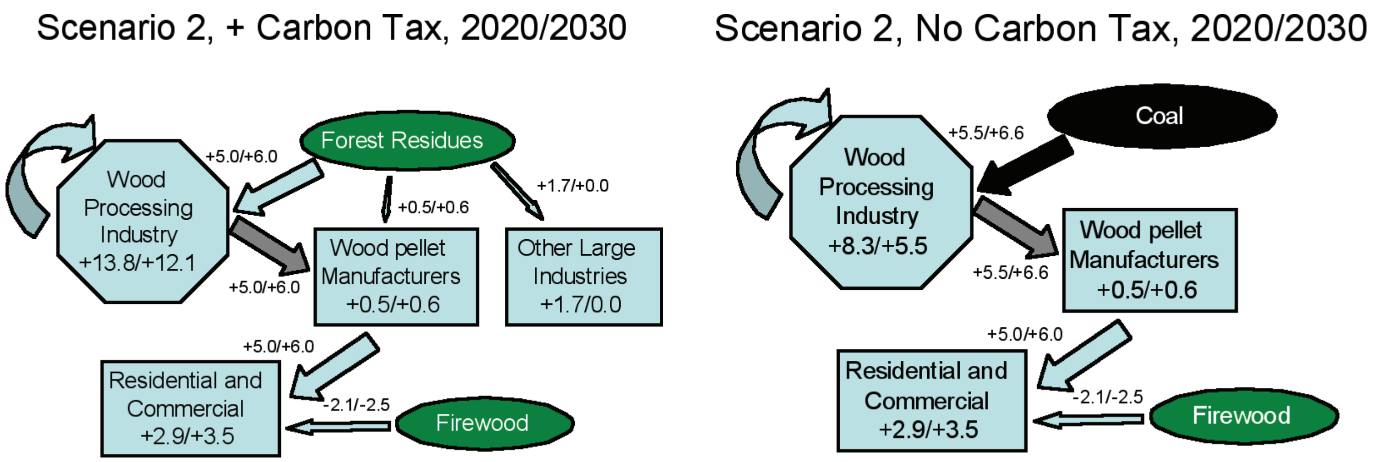


Figure 3. Biomass flows for scenario 2 (increased domestic processing) with and without a carbon tax of $15/t CO_2.

5. The proportion of logs processed domestically is 70% or greater out to 2030.

Our analysis has shown that, assuming the current proportion of biomass in the fuel mix of processing plants, the greatest gains in use of biomass are to be made by increasing the volume of logs processed domestically. To achieve the goals of the NZES without compromising economic wellbeing it is necessary to decouple economic gains from fossil fuel consumption. Heat derived from biomass for domestic log processing of value-added timber exports is a clear example of decoupling of export earnings from fossil fuel consumption. This would be easily measurable from a combination of Ministry of Agriculture and Forestry export statistics and the EECA heat plant database. This target should be regarded as a pseudo target as it is not likely that it will become an official target in this form

A key aspect affecting the achievement of all four of the targets suggested above is a shift in perception from regarding woody biomass as a waste product to regarding it as a valuable fuel. To this end it is suggested that efforts are made to improve technologies and develop skills in processing and handling biomass fuels. In particular, development of a set of quality standards, including considerations of moisture content and contamination, is likely to assist with the mainstreaming of woody biomass as a quality fuel.

WOOD PROCESSING CONTACTS

AREA OF EXPERTISE	NAME
Sawmilling	John Roper (NZ) Russell Washusen (Aus)
Log Quality / Grade Recovery	John Roper (NZ) Russell Washusen (Aus)
Timber Grading / Timber Utilisation	John Turner / Doug Gaunt (NZ) Russell Washusen (Aus)
Remanufacturing	Jeremy Warnes / John Turner (NZ)
Wood Quality	Dave Cown (NZ)
Alternative Species (to radiata)	John Roper / Russell McKinley (NZ) Russell Washusen (Aus)
Timber Drying	Steve Riley (NZ) Richard Northway (Aus)
Timber Engineering	Doug Gaunt (NZ) Richard Northway (Aus)
Kiln Design / Kiln Control / Dryspec	Steve Riley / Richard Dandoroff (NZ) Richard Northway (Aus)
Preservation and Antisapstain Treatments	Mick Hedley (NZ) Laurie Cookson (Aus)
Bioenergy	Per Nielsen (NZ)

CONTACTING Ensis

Ensis Australia
Telephone: +61 3 9545 8100
Freephone (within Australia only): 1800 231 051
Facsimile: +61 3 9545 2223

Bayview Avenue
Clayton, Vic 3168
Private Bag 10
Clayton South, Vic 3169
Australia

www.ensisjv.com
enquiries@ensisjv.com

Ensis New Zealand
Telephone: +64 7 343 5777
Freephone (within NZ only): 0800 231 051
Facsimile: +64 7 348 0952

Te Papa Tipu Innovation Park
49 Sala Street
Private Bag 3020
Rotorua 3046
New Zealand

CSIRO

scion

THE JOINT FORCES OF CSIRO & SCION