# Welsh timber resources and their potential within the construction industry

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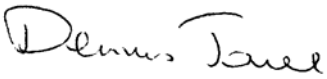
Signature 

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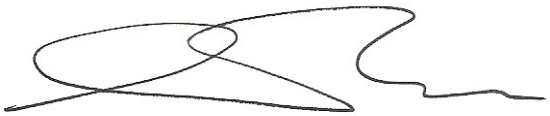
Signature 

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## Executive Summary

There is a wish to establish a greater use of locally sourced timber within the construction industry. This will have benefits in terms of minimising transportation costs and environmental impact, as well as helping to meet the desires towards affordable housing. Whilst much of the inventory has already been established, there are only a limited number of large enterprises currently utilising much of this material within Wales, with a similarly small number of companies actually utilising Welsh material.

Through a combination of desktop evaluations in the first instance, with the possibility of laboratory confirmations at a later date, it is proposed that material guidelines and best practice guidance be generated to facilitate greater exploitation of these local resources, based on designs suited to the locality.

In order to ensure a correct entry point for future work, a study has been funded by the Forestry Commission to determine the needs and requirements of one sector of the timber construction industry within Wales, namely the timber frame manufacturers. This report provides an overview of a questionnaire directed to this construction sector, as well as suggestions on possible options for increasing the potential of Welsh timber within this area.

## Contents

# 1 Introduction

There is a wish to establish a greater use of locally sourced timber within the construction industry. This will have benefits in terms of minimising transportation costs and environmental impact, as well as helping to meet the desires towards affordable housing. Whilst much of the inventory has already been established, there are only a limited number of large enterprises currently utilising much of this material within Wales, with a similarly small number of companies actually utilising Welsh material.

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## 2 Description of the project

The first stage of the Bridging the Gap project aims to assess the timber resource currently entering the construction market place. This was undertaken on two levels:

1. Assessing material supply, quality, and properties based on information gathered from a range of sources; and
2. Engaging Welsh timber frame manufacturers on their experience with locally resourced wood, as well as material from other locations.

The information gathered within this project is solely concerned with softwood supplies. Thorough market appraisals for hardwoods within Wales have already been compiled by groups such as Coed Cymru. Attempting to repeat this work would represent insufficient resource management, both in terms of current project funding and the activities of Woodknowledge Wales.

Much of the information gathered within this report has been as a direct result of Woodknowledge Wales (WKW) interaction, with valuable input from WKW, BRE, Bangor University, Coed Cymru, UPM Tilhill and BSW Sawmills. The information gathered herein demonstrates the potential of WKW as a means of extending the knowledge base.

# 3 Current understanding of the local softwood resource

There are several reports outlining the properties of UK grown softwoods, and it is not the aim of this report to duplicate this information, only to refer to some of the key issues and provide links to further reading.

## 3.1 Softwood timber supply and demand on a European level

There is an ever-increasing demand on timber supply worldwide, increased by the recent entry of new markets in countries across South-East Asia (especially China), as well as growing competition for raw feedstock from emerging technologies (such as wood fuel). This demand has been made worse by the collapse of the Communist Block timber marketing strategy, which has in effect led to countries such as Russia effectively withdrawing from the timber supply and processing markets for the last 10-15 years.

Tendencies of prospects for European timber has been comprehensively reviewed (UNECE FAO 2004), which reported:

(i) the demand for forest products will continue to increase for a minimum of a further 15 years, of approximately 1-2% growth annually.

(ii) European production of forest products will continue to increase up to 2020, to a level of 25-35% above current market size.

(iii) Europe is capable of reaching self-sufficiency for timber products provided that:

   a. European timber can remain competitive against products from other markets in both cost and quality

   b. The industrial processing capacity remains competitive through investment and well structured quality control.

(iv) There is a likelihood of a dramatically different sawn timber market in 2020 due to technological innovations, reduction in production costs, greater demands for quality, new markets and uses. Key developments are likely within processing, composite manufacture, adhesive technology and surface finishes. Some of these factors are already coming into practice, with new composites and adhesives entering what were seen as fairly stable market areas.

Whilst the demand for timber is expected to continue to increase for the medium term, there is also an ‘unknown factor’ based on the level of supply from Russia and other former Soviet Union countries. The Russian market became depressed following the collapse of the Soviet era, and selected regions within Russia are becoming to come back on line. This will lead to an increased supply of material on the market, which will depress prices further than those noted over the past 10 years. This will combine with (ii) above to effectively lead to a saturated market, which may further depress market prices (compared to prices of 10-15 years ago).

Figure 1 provides an overview of the total European trade in sawnwood over the past 40 years, showing the levels of imports, exports, productions and apparent consumption. It is interesting to note the apparent

increase in exports over the last 10 years, with individual countries identifying high value market opportunities.

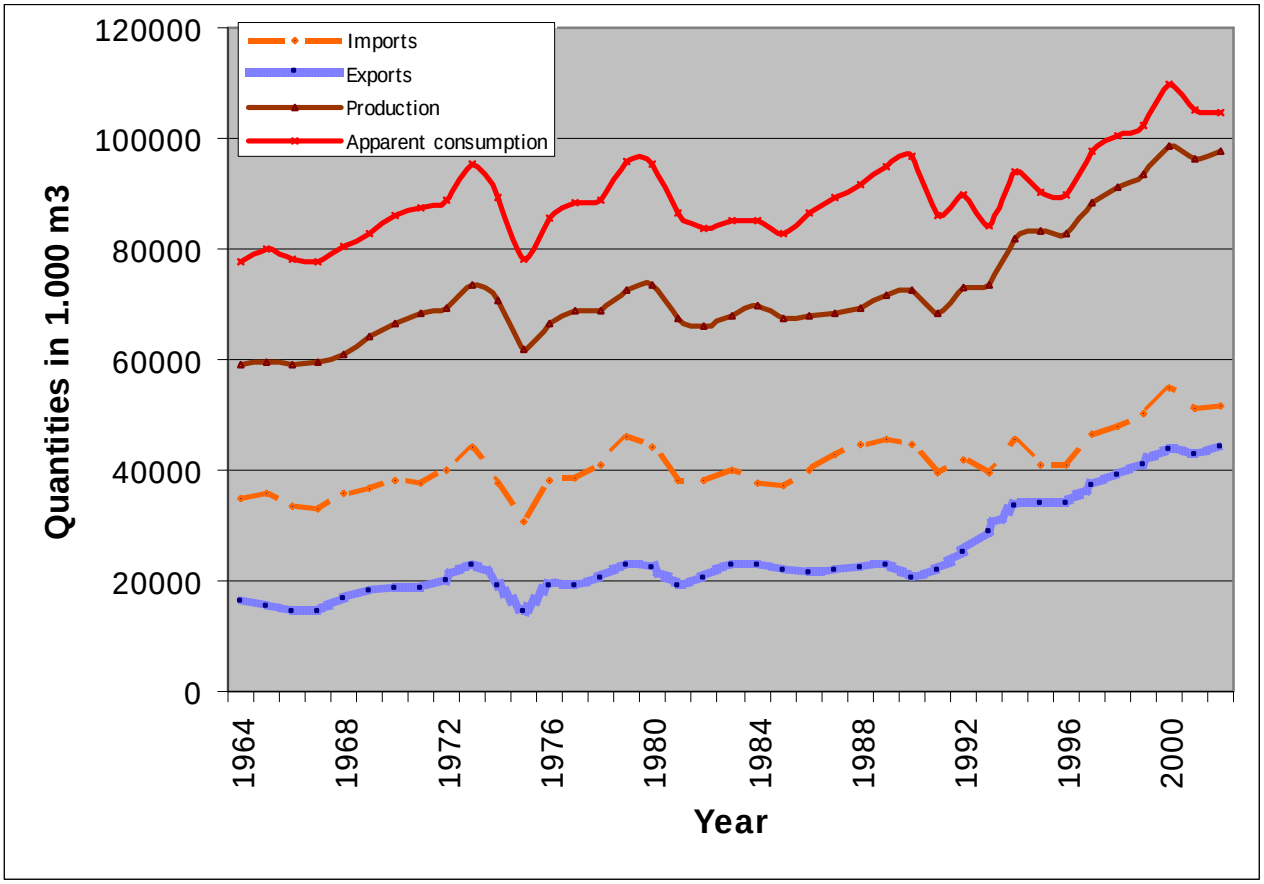


**Figure 1: Overview of production, imports, exports and apparent consumption of sawnwood in Europe over a 40 year period (Papadopoulos and Karagouni 2007).**

An example of this identification of a higher market value for resources within a Welsh context is the export of Sitka spruce wood chips and fibres by UPM Tilhill to sites in Austria and Finland as feedstock into the paper industry. The long white fibres obtained from Sitka spruce have been identified as better suited to paper manufacture than the locally available Norway spruce resource. On a broader European levels wood energy activities in Germany and Sweden have also led to an increased mobility for European timber stocks.

When the economic value of imports and exports is considered over the same period (Figure 2), there is an apparent increase in consumer faith in European timber and its products. The values listed in Figure 2 refer to all timber products, with the financial split between coniferous and non-coniferous products recognised as approximately 67%:33%.

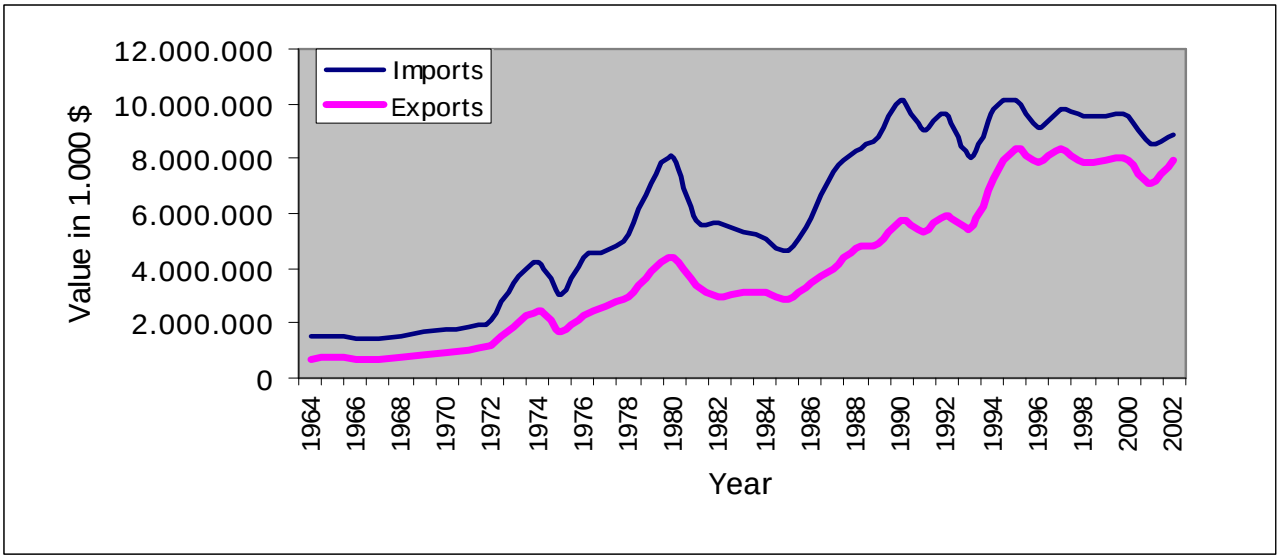


**Figure 2: Values of imports and exports of sawnwood over a 40 year period.**

Table 1 provides an indication of the UK's current position within European timber trade for sawnwood, compared to the overall European position. The UK is seen by other European forestry sectors as a market ideal for importing into, due to the ever-growing demand for timber products.

| Rating | Country | Imports (I) / 1000m$^3$ | Exports (E) / 1000m$^3$ | Production (P) / 1000m$^3$ | Capacity (Ca) / 1000m$^3$ | SS (%) | pE (%) | pEI (%) | pP(%) |
|---|---|---|---|---|---|---|---|---|---|
| 8 | UK | 8263.0 | 294.0 | 2539.0 | 10508.0 | 24 | -314 | 2811 | 88 |
| Total EU25 | | 51425.3 | 44301.6 | 97655.9 | 104779.6 | 93 | -7 | 116 | 55 |

Where:

SS (%) = Indicator of self-sufficiency (= P*100/(P-E+I)

pE (%) = Percentage of net exports based on overall production (=(E-I)*100/P)

pP (%) = National production consumed domestically (=(P-E)*100/P)

pEI (%) = Import:Export ratio (=(I/E)*100)

**Table 1: Position of UK within overall import :export : production : capacity within a European context.**

The most interesting fact arising from Table 1 is the level of self-sufficiency for the UK (2002 levels indicating this to be 24%). Such a low level of self-sufficiency (compared to the overall European sufficiency rating currently standing at 93%) places the UK 17$^{th}$ in a list of the 25 EU partners as of 2002. The current figures are as a result of a steady increase in self-sufficiency over the past 40 years, as is shown by the UK display within Figure 3 (Papodopoulos and Karagouni 2007).

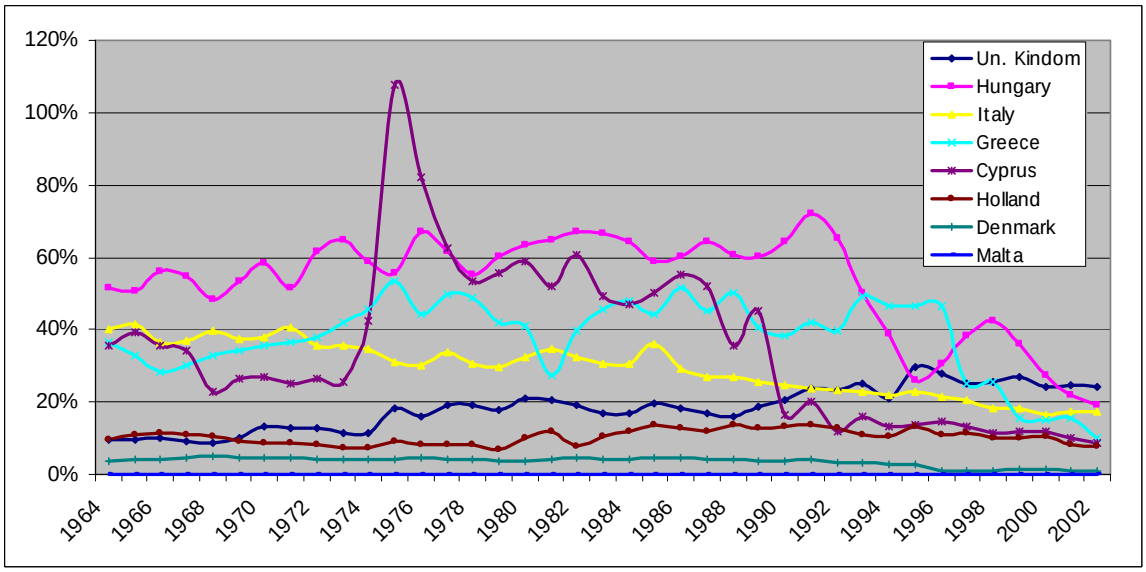


**Figure 3: Overview of self sufficiency ratings for selected European countries (Papodopoulos and Karagouni 2007).**

One of the more interesting facts listed within Table 1 is that 88% of UK produced timber is used within domestic markets, demonstrating the current demands. This supply factor is well established within Wales, with sawmills relying on local resources wherever possible. However, companies such as BSW do not wholly depend on locally sourced material, with additional material being transported from other regions in the UK due to economic factors. Currently BSW can source material from Scotland at a lower unit cost than Welsh resources, though such economic factors may vary. This high level of use of domestic timber within UK markets is shown graphically against those of other European counties in Figure 4.

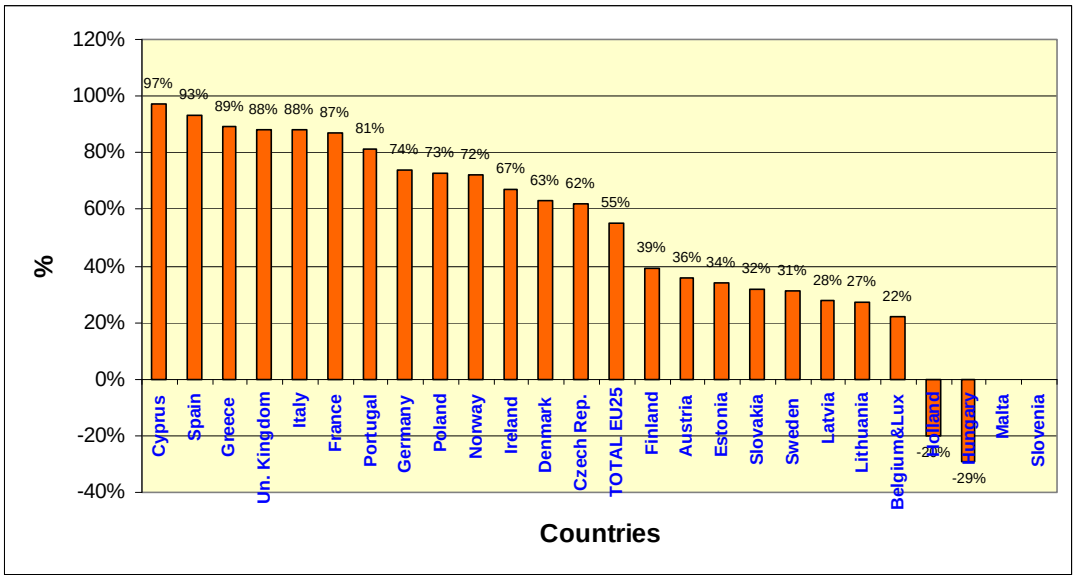


**Figure 4: Percentage of domestic timbers entering domestic markets for European countries in 2002.**

Table 2 shows the levels of imported sawn softwood for the UK and the overall European position, both in terms of volume and market value (in US dollars). The volume increases demonstrated within Table 2 are as would be expected, representing a growing market. What is more interesting is the limited value of these imported resources. It is apparent that different countries have different market import prices in place, either as a result of specific products or for the raw material. These price factors take into account the aggressive marketing necessary to ensure one nation's produce is exported over that of neighbouring countries.

| Rating (out of EU25) | Country | Vol. imported sawn softwood (1000 $m^3$) | | | Value of imported sawn softwood ($1000) | | |
|---|---|---|---|---|---|---|---|
| | | 1992 | 2002 | % change | 1992 | 2002 | % change |
| 1 | UK | 6899.3 | 7584.9 | 9.9 | 1340000 | 1353220 | 1.0 |
| | Total EU25 | 26464.5 | 37453.6 | 41.5 | 6365005 | 5805251 | -8.8 |

**Table 2: Overview of UK and overall European position on imported timbers between 1992 and 2002 (UNECE FAO 2006).**

Additional graphical interpretation of the UK timber market position both nationally and within Europe is given within Appendix A.

## 3.2 Softwood timber supply within Wales

Whilst this report will concentrate on the requirements of the sawmillers and end users of Welsh grown softwood timber, the viewpoints of the suppliers represents an essential piece of work.

One of the major concerns of Welsh sawmillers is the supply of material. There is an ever-increasing demand for Welsh timber, such that all available material is earmarked for specific uses. These demands will increase due to evolving markets in:

- Roundwood supply (for processing)
- Waste material for inclusion with brash bales
- Wood fibres for virgin pulp and paper manufacture
- Wood chips for composite manufacture
- Wood resources / biomass for energy.

The Forestry Commission represents the major forest ownership group in Wales, with 107,000 ha of forests. Softwoods account for 89% of this area (Forestry Commission 2006).

UPM Tilhill have indicated (Johnson 2007) that they manage approximately 13,000 ha of commercial woodland, accounting for approximately 25% of the total commercial sector, a fact agreed on by the Forestry Commission view of a total of 64,000 ha of privately owned softwood forest resources (Forestry Commission 2006). Annual harvesting by UPM Tilhill yields approximately 120,000 tonnes of roundwood per annum, with this value varying by around 20% for each individual year, depending on material supply

and market forces. Such examples are currently in place, due to the exceptionally high demand for Welsh grown timber. Some commercial growers have decided to bring forward harvesting by one year in order to take advantage of these inflated prices (which has to some degree been brought about by the limited supply from Finnish and Baltic States due to mild winter conditions restricting the removal of felled timber). The typical species range within UPM Tilhill managed sites is 70% Sitka spruce and 30% mixed coniferous species. These figures match those reported for other areas in Wales.

In the case of BSW, a strong supply chain has been established, though there is still concern over the level of stock held on site. Typically between 10-12 days of stock is maintained at the Newbridge-on-Wye site, which could prove problematic should there be difficulties in delivery (for example in periods of bad weather).

BSW have taken the decision to concentrate on a limited range of products (for example C16 graded boards of 47mm board width). Based on their commitment to deliver this product, BSW have established long-term marketing strategies with major outlets, so ensuring a strong price for their product. Based on such a strong market position, it is necessary to query whether there is a need to change marketing policy for Welsh grown timber, when a strong market already exists. Whilst there is a strong market for 47mm boards (meeting the supply of BSW's Newbridge-on-Wye site), there is a high demand for smaller sized material (typically 38mm board). There may be more individual samples of the smaller dimension boards extracted from a standard volume of material, but varying production between two differing dimensions might have affects on both markets (for example saturating the 38mm board market, whilst limiting supply of 47mm boards). Hence the decision to concentrate on a single process line would appear to be justified.

The opposite could also be argued in that there exists an opportunity for better utilisation of Welsh grown timber, though to compete with European whitewood imports, it may be necessary to consider secondary processing and re-engineering. Such actions will have an add-on cost to the timber product, which may take its sales price above that of the material currently being imported. Such actions would need to be carefully assessed when forming a business case for these new methods of processing. Chapter 6 will outline some of the options possible for innovation and adding value for Welsh timber.

## 3.3 Timber selection

As would be expected, in order to ensure a successful process, it is critical to have a ready supply of material. This has been among the assessment parameters for the location of the key sawmilling sites within Wales. Whilst R&D has been carried out on a wide range of timber species, these may not represent those immediately available, or more likely to the quantities required for a viable business opportunity. Table 3 provides an indication of the approximate breakdown of timber species grown in Wales (Forestry Commission 2002).

| Softwood species | Area ($10^3$ ha) | Hardwood species | Area ($10^3$ ha) |
|---|---|---|---|
| Scots pine | 5 | Oak | 43 |
| Corsican pine | 3 | Beech | 9 |
| Lodgepole pine | 6 | Sycamore | 7 |
| Sitka spruce | 84 | Ash | 19 |
| Norway spruce | 11 | Birch | 13 |
| European larch | 1 | Poplar | 1 |
| Japanese / hybrid larch | 22 | Sweet chestnut | 1 |
| Douglas fir | 11 | Elm | 0 |
| Other conifer | 6 | Other broadleaves | 18 |
| Mixed conifer | 0 | Mixed broadleaves | 8 |
| Total softwood coverage | 149 | Total hardwood coverage | 118 |

**Table 3: Overview of areas of major Welsh timber species (Forestry Commission 2002).**

Whilst this represents as close to the current understood standing of timber, it does not necessarily represent the amount of material available, or used by Welsh businesses. Many of the timber species actually listed within Table 3 represent timber species of little of no commercial value when considering potentials within the construction sector (i.e. for supplying C16, C24 or TR26). Among these 'unsuitable' timber species are hybrid larch (approximately 15% of the total Welsh timber area), and lodgepole / Corsican pine (6% of the total Welsh timber area). Thus there is an immediate reduction in potential production area of around 20% of harvestable area. These species might offer options through innovative work (as described within Section 6). Further reductions may be due to accessibility. Annually the Forestry Commission is currently making available 770,000 $m^3$ of overbark timber per annum within Wales, with an estimated 262,000 m3 also available from private woodlands.

The majority of material coming to market is Sitka spruce, with limited amounts of Douglas fir being co-processed and marketed as 'whitewood'. Specialist processing of some of the lesser species listed in Table 3 is only undertaken by the small sawmills, for niche market / personal use.

Recent information (Cooper 2007) suggested that for 2006 there was a total of 1.053 million tonnes of timber entering Welsh sawmills. The breakdown of this value in terms of its source is shown in Figure 5.

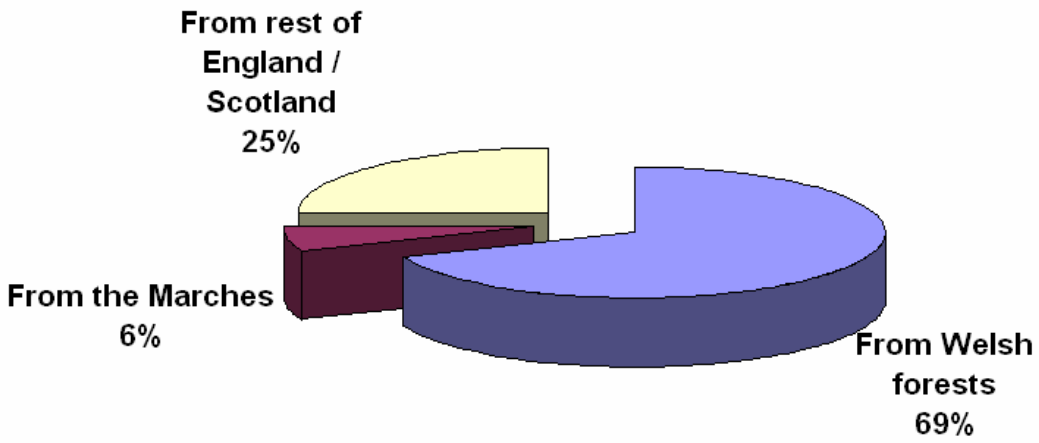


**Figure 5: Graphical representation of supply sources of timber processed in Welsh sawmills for 2006.**

For the Welsh supply (725,000 tonnes out of the 1.053 million tonnes), there are no fixed values immediately available to indicate what level of this material actually came from FC controlled land, or from private woodlands. However, it is possible to apply the current recognised levels of production from FC/private sources, which is 68% / 32%. Thus it may be possible to say that of the 725,000 tonnes of Welsh timber entering the sawmills, 493,000 tonnes originated from FC controlled sites, with the remainder (232,000 tonnes) from private woodlands. Current forecasts suggest that 770,000 tonnes will be available from FC land in 2007, and assuming the same percentage share between FC/private woodland, there will be approximately 262,000 of material from private woodlands. The suggestion of a greater supply of material from the private sector becoming accessible in order to cover some of the projected shortfall in Welsh timber supply does not appear logical under present forestry practices, since many of the private resources are present in “micro-stands”, where extraction and delivery to small, local or larger, regional sawmills are financially unacceptable under present conditions. Additional reasons for these financial unfavourable situations also include varying species present in these “micro-stands”, as well as reduced yield potential due to greater effects of peripheral regions in these stands (resulting in lower yields due to wind-induced stresses, and access routes reducing productive areas). Many of these micro-stands also contain considerable levels of hardwoods, which means that various process and product options may be obtained from a small timber coverage.

There is a potential error due to double counting of a limited amount of this material, depending on the involvement of more than one group (for example UPM Tilhill and FC operating the same woodland resource). The viewpoint is that the FC area information is correct due it being based on photographic evidence. In order to better understand the actual timber species and harvestable amounts, a survey is being undertaken by Mark York and George Johnson, funded by Confor. This study will look into the actual timber supply in Wales, and is expected to provide definitive information on this subject. Given this ongoing study, it is prudent to avoid repeating such a study, and to combine information at a later date.

Thus it would appear that the current input demand of Welsh sawmills is for more material than is currently available (currently operating at about 102% of the maximum available material). This also does not consider the mixed range of species that might be delivered from certain forest regions. There is also a

factor due to competitive markets, with raw timber being used for pulp and paper, composite board manufacture, energy resource and to a lesser extent for sawmills in England (excluding those operating in the Marches). Such competition for material has already been briefly discussed within Section 3.1, These competing markets will account for a varying percentage of the total Welsh timber supply, depending on market prices (both national and international). Thus there may be a shortfall of available material suited for constructional application each year, and this shortfall have to be made up by material brought in from other UK regions.

### 3.3.1 Genetic considerations

The use of genetically superior varieties of timber species is becoming more common, so that the speed of growth, reduction in branches and hence knots, straightness of trunk etc. can be fairly well controlled. This represents some of the major work undertaken by Forest Research, and is duly reported through their website. . In essence, improvements in stock selection will begin to realise benefits in the next 20-30 years. This represents a future production benefit beyond that forecast (for maximum production yield) estimated for between 2015-2020. There are two options, either an improved yield of timber, or an improved quality of timber.

The issues of improved genetic stock are beginning to be implemented in current replanting schedules, with 1050 ha of FC owned land and 516 ha of privately owned land undergoing replanting in 2005 (Forestry Commission 2006).

However these genetic considerations will not provide any benefits in short to medium term (as suggested above), and thus will not be considered further within this report.

## 3.4 Timber preparation

Having established the supply and demand for home grown timber (especially Sitka spruce), the methods used for preparation need to be considered. One method of ensuring a quality of supply of material is to ensure delivery of a constant quality. This may be better achieved through limiting the range of sizes of processed boards available, so concentrating delivery of a few ‘standard’ sizes. This has been the case with the larger sawmills within Wales, with the smaller mills often delivering some of the more ‘specialised’ sample sizes.

### 3.4.1 Sawing and drying

In order to achieve a good quality product, its conversion from the green state to timber ready for product manufacture is essential.

Deformation of sawn timber during and after the drying process, is the most important reason for down grading UK grown timber. Consultation with sawmills has indicated that between 10% and 12% of each kiln load is rejected due to excessive distortion occurring during drying. The deformation that occurs is related to the characteristics of the wood raw material (e.g. grain angle, density, juvenile wood content, compression wood, and knots) and to kiln schedules, drying technology and the post-kiln conditioning treatments. New drying techniques (e.g. faster drying processes, top-loading) might assist in overcoming these problems. However there is a need to find a balance between energy consumption (and its

associated cost), effects of elevated temperature on timber properties and in-service performance and process infrastructure (the capabilities of a given kiln drying system).

Pack design is a fundamental part of the kiln drying process. Correct stacking of packs will enhance the overall drying process and help to produce a high quality product, dried to a uniform moisture content, with very little or no distortion. This will make the product visually more acceptable to the buyer.

Analysis of data indicates significant variation of moisture content, with considerable variation from individual timber sources. This represents the most important factor in guaranteeing a standard product, since uniform final moisture content is seen as an essential processing parameter. The presence of a single dimension will limit the level of distortion resulting from differing drying characteristics between mixed batches of wide (200 mm) and narrow (100 mm) pieces. If this is not possible, wider pieces should be monitored for the desired moisture content, even if this means over-drying narrower pieces.

Issues relating to differing lengths of samples within a pack tend only to occur within hardwood processing, and as such will not be considered further within this report.

To minimise distortion during the drying process, the stickers must be positioned at regular intervals across each layer of pieces thus providing support to each successive layer. Pieces within a pack are therefore supported by those stickers above and below each layer as shown in Figure 6. The frequency of stickers will depend on the timber being kiln dried, with smaller cross-section material requiring a higher frequency of stickers than larger dimension material. In turn each pack should be supported by dunnage positioned below each column of stickers, supported by the kiln floor or bogie (not shown in Figure 6).

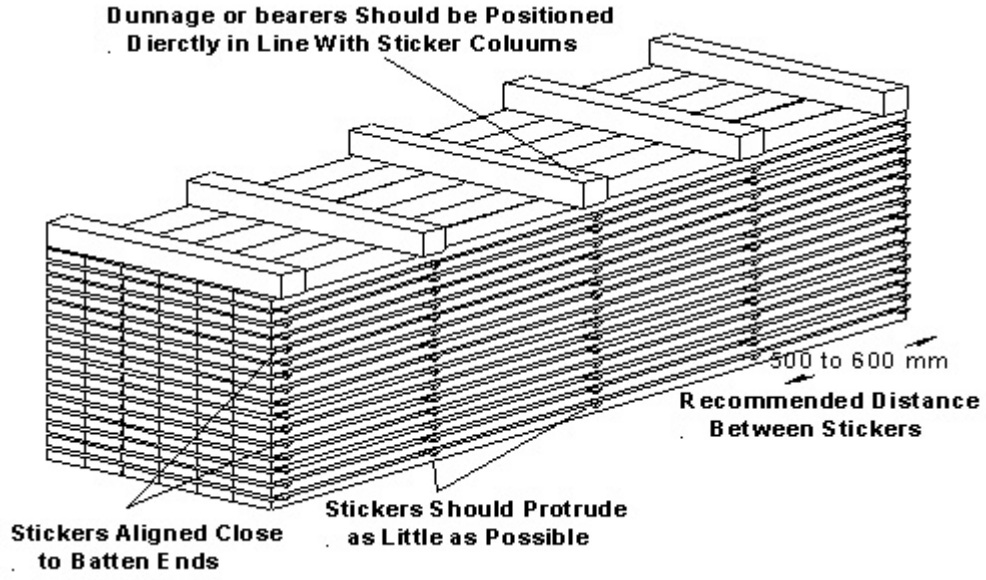


**Figure 6: Good stacking system for kiln drying for large cross section material**

### 3.4.2 Storage

Once timber has been sawn and dried, it may be necessary to store prior to its modification or its transportation to processors or end users. During this stage it is important that no rewetting occurs. Whilst

this is of a reduced effect for modified timber, there is still a risk of the onset of biological degradation over long periods of time. In addition, rewetting may increase the risk of warping coupled with irregular loading which may in turn lead to material rejection.

It is recommended that timber should be stored in a dry, well ventilated area, carefully stacked in packs (similar to those in correct kiln drying procedures). In order to reduce the uptake of moisture, stickers should be removed from between pack layers. Maintaining a structured storage system similar to that used during kiln drying will help an even weight distribution, so reducing the risk of twist, warp or creep during storage.

### 3.4.3 Compression wood

Compression wood is a type of reaction wood which is produced by the tree in response to changes in its environment (e.g. constant wind damage). It is more common in fast-growing trees, where susceptibility to environmental changes is more pronounced, and when exposed to prevaling winds. If a tree comes under an external force affecting its natural equilibrium position, compression wood is produced. This take the form of promoted growth. The result is an eliptical growth pattern (Figure 7). Compression wood may form in any timber species, and in any location. However, when exposed to prevailing coastal winds there is a greater tendency for compression wood to form. Thus there is expected to be a high level of compression wood on material from some of the exposed hillsides in Wales, especially from trees originating from the periphery of a growing stock, or from larger specimens (i.e. affecting the higher reaches of the tree compared to the more protected section of the lower trunk).

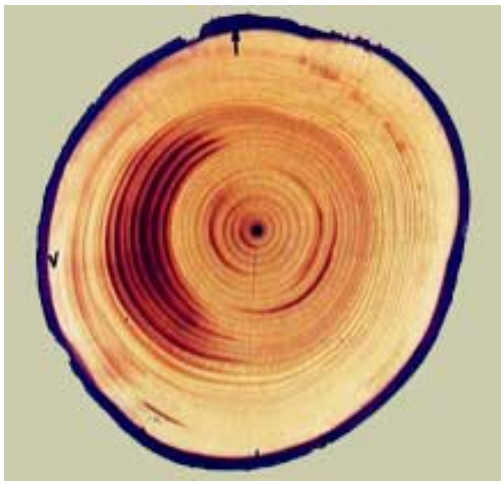

**Figure 7: Formation of compression wood.**

Because of the “prestressing” that occurs during the growth of the tree (especially where there may be high levels of wind loading, characteristic of Welsh hillside plantations), the timber will contain residual stresses which are transferred to the behaviour of processed structural elements. Softwood trees are known to have tension on the inside and compression in the outer layers. If the tree is moved out of planting alignment for whatever reason, extra compression wood will be laid down on the low side to restore the tree to alignment.

The stresses in the wood are generally released when the trunk is cut into lengths of sawn timber. If there is a residual stress differential across a piece of timber, this may lead to twist, cup, bow or spring in the piece. The movement takes place to minimise the residual stresses in the wood. Most sawmills use a range of

cutting patterns that minimise the residual stress differential in individual lengths, depending on the length and circumference of logs being processed. This is the reason for most sawmills to prefer to operate within fixed dimension parameters.

As the movement of the timber is accentuated by moisture movement, the deformation becomes more apparent when the wood dries, such that the following processing defects may be noted:

- Cup - Deformation of the cross-section, so that the edges move upwards.
- Bow - Deformation over the length of a board in the minor axis direction.
- Spring - Deformation over the length of a board in the major axis direction.
- Twist or warp - Twisting of the board so that successive cross-sections are not parallel.

Examples of each are shown in Figure 8.

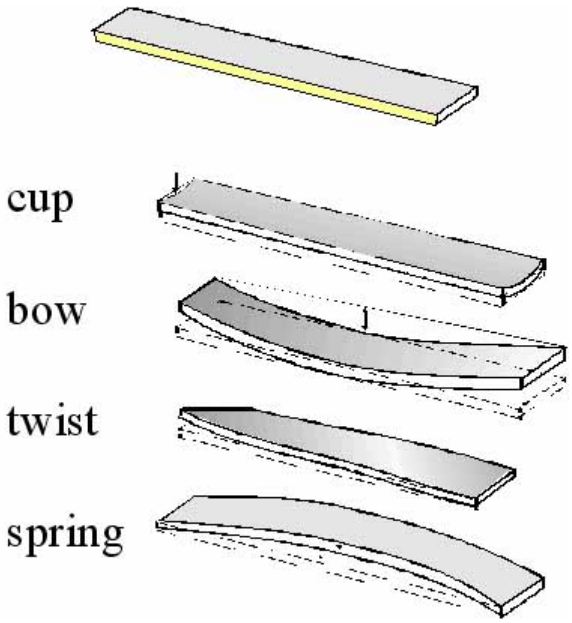


**Figure 8: Diagrammatic representation of effects of residual stress relief**

Each of the effects shown in Figure 8 are common factors encountered with Welsh grown Sitka spruce, especially in larger dimension samples.

The problems due to compression wood may be reduced by timber selection, sawing practices and by improved drying conditions. There is also a reduction in these properties with smaller sized samples.

### 3.4.4 Dead knots

Knots are common features of timber. Dead knots are formed when an expanding trunk envelopes branch stem regions that have previously died, that is the trunk grows around a ‘dead site’. Dead knots often fall

out during processing as they do not form a continuous part of the wood. They may also provide a focus for biodegradative attack.

The presence and size of knots (especially dead knots) will play an essential part within timber selection. Some UK grown species such as Sitka spruce commonly have a lot of small knots. The presence of these smaller knots may not prove too problematic during some innovative processes (such as wood modification), with loosening and/or splitting of sound knots also possible in certain cases. Larger knots may need to be removed, as they will have a greater tendency to split or become loose. The production of clear engineered boards by jointing several smaller pieces of clear material may represent a viable option.

The grading of timber represents a well established process, whether as visual or stress grading. Visual grading has been covered to a degree within BRE Digest 500 (Jones and Suttie 2006) as well as BS 4978. Stress grading can be found in BS 5268, along with visual grade assignment based on visual grading to BS 4978. BS 4978 with give the grading criteria for the visual grades.

### 3.4.5 Growth rate

The growth rate may be measured by the width of the growth ring. Usually the width of the growth rings increases as the cambium gets older and after reaching a maximum width, it starts to decrease until the tree becomes very old. Changes may be possible from this typical scenario through silvicultural practices. In order to achieve a more accurate indication of changes to growth rate, an index, determined from the cambium age and apical age may be used.

Within a tree species, the basic wood density varies between genotype, stands and individual trees. Most of that variation is due to variation in wood basic density within individual trees between earlywood and latewood, from pith to bark, from ground level upwards and due to growth rate.

The wood basic density usually increases with the age of the tree, often linearly. However, there is also a decrease of wood basic density with increased growth rate.

In general, the fast growing species, and more specifically younger specimens, may not be suitable for use where strength is important (strength is reduced with faster grown and less dense timber). However for cladding, where the timber is only present as a non-load bearing product, this would not pose such a problem.

## 3.5 Natural durability of Welsh timbers

The natural durabilities of UK timbers are regarded as well established, with standard texts covering reporting evaluated durability tests (Henderson 1956, Farmer 1972). Many of the studies reported within these texts were undertaken several decades ago, as is demonstrated by results of tests undertaken by BRE on timber specifically sourced from Wales (Table 4).

| Date | Timber species | Origin of timber | Average life (years) at test site | | |
|---|---|---|---|---|---|
| | | | Princes Risborough | Thetford | Dolgellau |
| 1933 | Grand fir | Leighton Hall, Welshpool | 2.8 | 5.3 | 10 |
| 1933 | Sitka spruce | Leighton Hall, Welshpool | 2.9 | 6.4 | 15.2 |
| 1936 | Silver fir | Rabbit Bank, Leighton Hall | 7.4 | 8.5 | 11.1 |
| 1936 | Grand fir | New House Planting, Leighton Hall | 5.5 | 7.6 | 9 |
| 1936 | Sequoia | Leighton Hall, Welshpool | 18.4 | 11.5 | Not completed[1] |
| 1938 | Ash | Cilfaigan Park, Coed-y-mavis | 4.8 | 4 | Not planted[2] |
| 1958 | Japanese larch | Fedw Wood, Tintern | 10 | 10.1 | Not planted[2] |
| 1958 | Norway spruce | Coed-y-Brenin Forest, Dolgelly | 5.1 | 7.5 | Not planted[2] |
| | | | | | |
| 1938 | Sessile oak | Buckland, Brecon | 41.9 | 29.9 | Not planted[2] |
| 1938 | Sessile oak | Buckland, Brecon | 16.1 | 28.5 | Not planted[2] |

[1] Test not completed due to abandoning of test site at Dolgellau, due to inactivity of water-logged peat soil system

[2] Dolgellau site no longer part of the test site portfolio

**Table 4: Overview of natural durability**

Many of these tests were carried out prior to the currently recognised European standard (EN252), ad used an assessment method developed by the Forest Products Research Laboratory (the forerunner of BRE Timber). The durability classifications were based on the length of time the stakes survived in service, as described in Table 5 (FPRL Tech Note 40).

| Classification according to FPRL Tech Note 40 | Expected service lifetime of sample (years) | Revised classification name | Durability rating according to EN350-2 |
|---|---|---|---|
| Very durable | >25 | Very durable | 1 |
| Durable | 15-25 | Durable | 2 |
| Moderately durable | 10-15 | Moderately durable | 3 |
| Non-durable | 5-10 | Slightly durable | 4 |
| Perishable | <5 | Not durable | 5 |

**Table 5: Durability classification and service life performance for in-ground contact stakes.**

Whilst there is no doubt over the scientific validity of these results, forestry practices have changed considerably over that period of time. There is a strong likelihood that the results quoted in Table 4 refer to material from virgin stands, and/or of a differing degree of maturity to those currently felled. The many timber species, this would not prove an issue since results averaged from several sources result in a durability classification in the mid-range of its class. Discrepancies may occur where classifications occur within a borderline between two durability boundaries. This was recently considered by BRE, whereby species such as homegrown Douglas Fir, Western red cedar and Larch were downgraded a durability classification. This need would be more apparent for results for Welsh timbers alone (instead of considering the whole UK picture), since the warmer wetter growing conditions present in Wales realise slightly faster growing conditions than those for the rest of the UK.

BS EN 335-1 describes five Use Classes (formerly termed Hazard Classes) of timber exposure:

1. Internal, with no risk of wetting
2. Internal with risk of wetting
3. External, above damp proof course
4. In permanent ground contact or freshwater
5. In permanent contact with seawater

The use of Welsh timber within construction falls within categories 1-3 in most cases, with limited risk at the timber frame/foundation interface of permanent ground contact (Use Class 4). It is in these regions of possible exposure to higher risks that it is prudent to consider using timbers and/or treatments more suited to the higher risk class. Thus, depending on the use, there may be a need to preservative treat material.

BRE Digest 429 gives the natural durability classifications of a large number of species, together with their resistance to preservative treatment. Natural durability classifications are also given in BS EN 350 - 2 and BS 5268: Part 2. Some of these timbers are not available from sustainable sources or with appropriate Certification. Table 6 shows values for some commonly available British grown species. The natural durability ratings given relate to UK conditions, and refer to the heartwood and fungal attack only.

| **Timber Species** | **Natural Durability of Heartwood** | **Treatability of Heartwood** | **Treatability of Sapwood** |
|---|---|---|---|
| Sitka spruce | Not durable to slightly durable | Difficult to treat | Moderately easy/difficult to treat |
| Norway spruce | Slightly durable | Difficult/extremely difficult to treat | Difficult to treat |
| Douglas fir | Moderately to slightly durable | Extremely difficult to treat | Moderately easy/difficult to treat |
| Larch | Moderately to slightly durable | Extremely difficult to treat | Easy to treat |
| Scots pine | Moderately to slightly durable | Difficult/extremely difficult to treat | Easy to treat |
| Corsican pine | Slightly durable | Extremely difficult to treat | Easy to treat |
| Lodgepole pine | Moderately to slightly durable | Difficult/extremely difficult to treat | Easy to treat |

**Table 6: Natural durability of timber species in ground contact (BS EN350-2)**

# 4 Requirements of the construction industry

This study considers the timber frame industry within Wales, based on these companies' responses to a questionnaire (contained within a stand alone document to accompany this report).

Tables 7, 8 and 9 provide a list of timber frame companies operating in North Wales, Mid Wales and South Wales respectively that were contacted within this study.

| **Company name** | **Location** |
|---|---|
| Regency Timber Buildings | Wrexham |
| Country & Leisure | Corwen |

**Table 7: Timber frame companies contacted in North Wales**.

| **Company name** | **Location** |
|---|---|
| Framewise Ltd. | Presteigne |
| Cartrefi Ffosaron Homes Ltd. | Llandysul |
| Lowfield Timber Frame | Welshpool |
| Dyfed Homes | Aberystwyth |
| AC Roof Trusses | Welshpool |
| Atlantic Homes | Llandysul |
| Cartrefi Gem | Llandysul |

**Table 8: Timber frame companies operating in Mid Wales**

| Company name | Location |
|---|---|
| Goodwins Timber Frame | Caerphilly |
| Timber frame (Wales) | Ammanford |
| Timber developments | Bridgend |
| Benfield ATT | Caldicot |
| Holbrook Timber Frame | Bridgend |
| Firwood Homes | Milford Haven |
| Fforest Timber Engineering Ltd. | Swansea |
| RG John Timber Frame | Porth |
| Frame 2000 | Penarth |
| Century Homes | Tredegar |
| Stately Albion Ltd. | Newport |
| Big Timber Ltd. | Llanybri |
| Towy Homes | Peniel |
| Redwood Homes | Pencader |
| Seven Oaks Timber Engineering | Neath |
| Newport Roof Trusses Co. Ltd. | Newport |
| Talbot Timber | Pembroke Dock |
| Donneybrook Construction | Caerphilly |
| Cowlin Timber Frame | Pontypridd |
| Heritage Designs | Cardigan |
| Edenhouse (UK Frame) Ltd. | Llanelli |
| Cartrefi's Bryn Homes | Newcastle Emlyn |
| Manderwood Timber Engineering Ltd. | Neyland |
| Swansea Timber Frame | Swansea |

**Table 9: Timber frame companies operating in South Wales**

Whilst these companies represent those listed as timber frame manufacturers, some were found to be incorrect listings (for example some companies were found to be garden shed manufacturers, whilst incorporating timber frame systems, did not comply with the aim of structural frame systems).

## 4.1 Summary of questionnaire

In order to obtain as accurate a response from the companies listed within Tables 7-9, a questionnaire was drafted and circulated (see BRE report 234 170 for the full questionnaire, and complete results). The main theme of the questionnaire was to ascertain how much Welsh timber is currently used within timber frame construction in Wales. Where possible information on grades of material and their origins were sourced. This would help ascertain the potential for Welsh timber within a growing area of the construction industry.

Along with determining the origin of material, it is also essential to establish the needs of the timber frame industry. Thus the second part of the questionnaire deals with attempts at sourcing Welsh-grown material, as well as experiences of Welsh timber.

Thus, the following questions were submitted to the Welsh timber frame companies identified within this study:

1. What is the quantity of timber used annually, either by volume or value ( previous surveys have shown that SME owners usually know the value rather than volume, this can then be converted to volume)

2. What percentage is C16
   Countries of origin

3. What percentage is C24
   Countries of origin

4. What other grades are used, percentage split if possible
   Countries of origin

5. Have you attempted to source Welsh grown product, with what degree of success

6. What problems, if any, have you experienced in the supply of all product

The results will be compiled into a comprehensive survey report that will be submitted as a stand-alone document.

## 4.2 Results of questionnaire

Out of the original 33 companies identified through compilation of telephone directories / previous databases, a total of **26** companies were successfully interviewed. The remaining 7, for a variety of reasons proved impractical. This resulted in a **79%** survey success rate.

Table 10 provides an overview of the volumes of timber used by the companies interviewed, based on C16, C24 and TR26 used in current construction programmes.

| Company I.D. | Total timber volume ($m^3$) | Volume C16 ($m^3$) | Volume C24 ($m^3$) | Volume TR26 ($m^3$) |
|---|---|---|---|---|
| 14 | 450 | 450 | | |
| 10 | 4000 | 2600 | 600 | 800 |
| 31 | 500 | 350 | 150 | |
| 29 | 200 | 170 | 30 | |
| 15 | 11500 | 7500 | 100 | 3900 |
| 6 | 1800 | 360 | 360 | 1080 |
| 33 | 325 | | 325 | |
| 23 | 72 | | 72 | |
| 11 | 2140 | 1280 | 650 | 210 |
| 36 | 2030 | 1730 | 300 | |
| 37 | 2000 | | | 2000 |
| 38 | 3000 | 450 | | 2550 |
| 25 | 1000 | 800 | 200 | |
| 7 | 3000 | 1500 | 900 | 600 |
| 16 | 500 | 450 | 50 | |
| 40 | 1125 | 1125 | | |
| 39 | 300 | 75 | | |
| 42 | 5520 | | | 5520 |
| 2 | 2750 | 1500 | 500 | 750 |
| 35 | 3870 | 353 | | 3517 |
| 41 | 1525 | 1200 | 145 | 180 |
| 21 | 5700 | 4600 | 1100 | |
| 30 | 750 | 750 | | |
| 4 | 2200 | 1100 | 1100 | |
| 9 | 8100 | 4860 | 3240 | |
| 26 | 36 | 36 | | |
| **TOTALS** | **64,693** | **33,239** | **9,822** | **21,107** |

**Table 10: Responses of companies to levels of structural graded timbers uses in business activities.**

It would appear from Table 10 that there is a considerable timber frame business activity within Wales, demonstrating the progressive viewpoint of many of these companies in applying modern construction trends. The overall feedback from the interviewees was that the sector is experiencing strong growth and demand will increase by at least 10% per annum. This will result in a timber frame supply volume of approximately 100,000 $m^3$ within 5 years. Two companies informed of expansion plans which included the acquisition of additional premises. Others may follow suit, so increasing demand for construction grade timber.

However, due to the complex nature of the local / regional supply chain, direct identification of Welsh grown timber proved to be almost impossible. One company reported trying to establish a supply chain for C16 through a local sawmill but this had floundered after a few months due to commercial difficulties.

Over 80% of respondents had not attempted to source Welsh grown timber but indicated that they would be prepared to provided the material was readily available and competitively priced. Among the key criteria stated was the desire to minimise the effects of high transport distances. Welsh grown C16 is available from BSW, though only at 47mm thickness. The majority of constructors consulted during this study preferred 38mm material, primarily on a cost basis. This might open opportunities for Welsh sourced C16.

Two respondents reported the total use of C24 within their entire construction programmes at the insistence of the architects involved and several other companies that specifications often demanded Scandinavian produced timber. This suggests the need to demonstrate that Welsh timber is ‘fit for purpose’.

However a number of companies reported the use of Welsh grown timber for non-structural purposes and exterior cladding, particularly Douglas Fir. Such use of alternative timber species for non-structural uses was client driven. Many of these non-structural uses represents key developing markets for the Welsh non-Sitka spruce softwoods. Attention should also be drawn to a recent BRE Digest (Jones and Suttie 2006) outlining the potential for Sitka spruce as a cladding material.

One of the key observations from the questionnaire were comments registered regarding the comparative density of Welsh grown stock in comparison to Scandinavian/ Baltic grown timber. This would be of vital importance in influencing the decisions of architects and specifiers, as a means of providing a degree of product quality. It may be prudent to undertake such evaluations and report findings as part of a CPD-style event, aimed at generating new markets for Welsh softwood species.

# 5 Viewpoint of timber producers

Anecdotal feedback to Woodknowledge Wales from a variety of Welsh sawmillers suggests that the supply of softwoods from Welsh forests is not meeting demand. The downturn of outputs predicted in the Jaakko Poyry study of 2004 is now happening. This was borne out by the sawmilling participants at the Welsh Forest Business Partnership / Woodsource Wales seminar in Newtown on 19th February 2007. There, emphasis was placed on private forest owners to increase outputs to make up the shortfall in FC production. Such a viewpoint re-enforced the comments gathered on 31st January 2007 at a Woodknowledge Wales meeting with senior management of BSW at Newbridge on Wye, who advised that they were importing timber from the Republic if Ireland and the Isle of Skye to maintain normal production. Indeed, the current market position dictated that, on average 2 weeks supply of timber was present at Newbridge on Wye. Thus, difficulties in supply (for example due to inclement weather) could effect production capacity on site.

The smaller mills are effectively 'rationing' their supplies into product that is most profitable to them. This is indicated by the strong demand for fencing materials, decking and the like, whilst pallet manufacturers have reported material shortages in some instances.

A major factor affecting timber demand within Wales and the UK in general has been the mild winter in the Scandinavian and Baltic countries. This has led to harvesting difficulties and adversely impacted on the supply of saw logs and consequently on the supply to market of certain products.

For the first time in several years, Canadian structural grade lumber has been imported directly into South Wales ports, a shipload of 10,000 $m^3$ being recently received into Newport. This demonstrates the need for structural grade material as well as the guarantee of supply. Perhaps the most interesting aspect of such imports is the price paid for Canadian Lumber Standard (CLS) material (typically £140 per cubic metre), as opposed to current prices achieved by home grown material (typically £170 per cubic metre). This represents a greater market value achieved by home grown timbers by over 20% compared to CLS material. However the noted drying deformations preclude the use of home grown timbers on smaller cross section material. This may be overcome through the use of thicker cross-sectional material, but this would place home grown material at a financial disadvantage. Based on this, it would appear illogical for home grown material to try and compete against low price imported material, but maintain its current market position, or explore new processing options. Home grown prices represent a considerable mark-up compared to current overbark standing of £7.13 per cubic metre (FC 2006b). However annual price statistics (FC 2006b) show there has been a downturn in prices of 4% between 2005 and 2006.

There has been considerable development of innovative use of short length and small diameter timber in Wales undertaken by Coed Cymru over a number of years. This has primarily focused on hardwoods but the principles are transferable. The process commences with woodland management outputs fed into a tractor mounted 'double slabber' saw to produce 100mm x 25mm boards of length 1m or more.

A range of furniture was then developed under the 'brand' of Welsh Angle which is the simple joint developed to optimise this small section material. Its simplicity and ease of manufacture has enabled a

positive transition for anyone wishing to use the system. The Welsh Angle has proved successful with farmers wishing to diversify, start up business and social enterprises as examples of users.

Coed Cymru then followed on with developments in lamination of this base material developing windows utilising small section and short length timber, primarily oak and sweet chestnut which also required very little wood working skill to produce. The concept has been transitioned into volume commercial production by Coed Derwen Joinery in South Wales who use CNC machines and aerospace standard jigs to manufacture windows to 0.1mm accuracy.

Various wood modification process can dramatically increase the applications for under utilised species such as beech and hemlock. Some of these modification process are now beginning to find their way into mainstream joinery with the potential for increased value addition were little or none previously existed. Wood modification offers greater benefit to softwood species other than Sitka spruce.

Many of the above represent concepts that would require more detailed species mapping of the Welsh woodland resource. Such activities could provide future actions within the “Bridging the Gap” programme.

# 6 Identifying a way forward

Having established that Welsh timber appears to be operating close to its maximum potential

The recent Business Health survey (Forestry Commission 2005) identified the following points as essential for continuing business opportunities:

- Investment in implementing and keeping up with new capital
- and machinery;
- Finding new business and extending customer base;
- Increasing value added;
- Expanding range of services and products;
- Improving quality of service;
- Promotion and marketing.

Whilst these points relate to UK businesses in general, the same is true for Welsh companies.

There are two possible options that may be considered:

- Keep the industry as it is – why compete with imported material. Many companies might agree with this concept, as they have a well-structured business platform, generating a continuous income. Whilst such income streams might not represent high profit schemes, they are seen as sufficient.

- Consider radical product ranges, better utilising the softwood supply and recognised properties. In order to do this, a range of possible products and/or processes will need to be identified, development programmes established, as well as undertaking necessary certification systems. However the end result may be a product capable of generating considerably higher revenue than conventional products. Whilst these may have an initial operating losses, the chances of reaching profitability will be reached at a quicker rate than conventional product ranges.

The predominant silvicultural system plant, thin or no thin, clearfell and replant determines the quality of softwood available in Wales. It is a high cost option with most of the cost incurred in early life of the crop. Opportunities for improving net margins by cost reduction or economies of scale are limited when compared with overseas competitors. It would appear that the Welsh softwood resource is yielding approximately its sustainable maximum. Any expansion of the resource will have no impact on the market place for a few decades. The sawn product is well positioned in the commodity markets for fencing, carcassing, pallet wood etc often punching well above its weight compared to imported material of higher specification. The sawmills have done an excellent job of making the most of an unpromising raw material although the rest of the supply chain can only function with the external support traditionally provided by grants and tax incentives or direct intervention.

When considering the technological upgrading of local material, the following alternatives provide examples of what may be considered:

*Pre-processing to overcome the inherent stability problems:*
1. Lamination
2. Engineered profiles
3. Heat treatment or impregnation processes (not Sitka spruce)
4. Green timber processing
5. Novel processing technologies for increasing permeability (especially for Sitka spruce)

*Subsuming the timber cost into a special process:*
6. Ty Unnos, a building system based on box beams
7. Laminated joinery.

*Moving an element of the product into a higher value commodity market:*
8. Producing joinery timbers from slower grown (suppressed) material
9. Producing building claddings from fencing materials

Table 11 provides a summary of each of these, in terms of their implementation.

| Option | Advantages | Disadvantages | Net change of value | Implications |
|---|---|---|---|---|
| 1. Lamination | Good stability<br>Established market | High cost | Negative | Unlikely to happen |
| 2. Engineered profiles | Good stability<br>Inexpensive | Unfamiliar product | Positive | R&D required<br>Certification required |
| 3. Heat treatment and impregnation | Improved stability<br>Improved machining<br>Improved durability | Unsuitable for spruce | Positive | Investment required |
| 4. Green timber technology | Lower processing costs<br>Improved quality | Unfamiliar process<br>High set up cost | Slight positive | Investment required<br>R&D required<br>Certification required |
| 5. Novel processing (e.g. microwave pre-treatment) | Suited for spruce<br>Increased permeability<br>Range of secondary treatment options | High cost<br>Unfamiliar | Positive | Investment required<br>R&D required |
| 6. Ty Unnos | Improved stability designed around the raw material | Unknown costs<br>Unfamiliar<br>Need drying to 14% | Positive | R&D required |
| 7. Laminated joinery | Well established high value product | Needs drying to 14% | Positive | More kilns required<br>Better selection at mill |
| 8. Selection of Joinery timbers | Simple established markets | Needs drying to 14%mc | Positive | More kilns required<br>More selection of growing stock |
| 9. Selection of cladding | Simple established market | Poor durability of home-grown softwood | Positive | Better use of chemical treatments |

**Table 11: Overview of possible developments for Welsh softwoods**

It is important to recognise that Table 11 only represents a brief overview of what might be possible for Welsh softwood species. Each topic within Table 11 can be delivered as a stand-alone project, capable of providing a means of increasing wither the quality or the value of Welsh-based softwoods, especially Sitka spruce.

Many of the possible developments listed within Table 11 can be seen as complimentary to other work investigating novel uses for local timbers. One such project ongoing at BRE is considering the use of local timbers for timber piling possibly suited for use in construction, bridges and other foundation units (Reynolds 2007). Among the key developments within this work has been the use of glass fibre reinforced polymer (GRP) encapsulation of timber piles to provide greater longevity in service. These are currently being placed under test to generate real service life data.

A successful aspect of the timber industry within Wales and the UK has been the ability to think ‘outside of the box’, and create innovative solutions capable of providing considerable financial benefit to the timber sector. Recently this has been demonstrated through the work of Coed Cymru for locally sourced hardwoods. Investment in new technologies may prove beneficial for the upgrading of locally sourced softwoods.

It is also possible to envisage a co-ordinated approach taken towards the supply chain to ensure the products travel the minimum of distances In many aspects the situation replicates the foodstuff supply chain whereby little attention has, to date, been paid by the supermarket groups to localising supply and consequently created farmers markets and consumer demand for indigenous products. The current position in the timber industry is that the major timber merchant chains purchase the outputs from Welsh mills and then re-distribute on a demand basis throughout their sales networks regardless of localisation and Welsh grown product is mixed in with imports.

The opportunity now exists through the identification of market consumption in Wales to encourage active localisation. This process will obviously require further investigation and development. Over the next few decades other influences will come into reality which will demand localisation, carbon taxes and other legislation. These may seriously impact on costs of importation etc. creating new gaps to be bridged as cursory inspection of planned and proposed E.U. will indicate.

The process of localisation of all grades of product will be lengthy, consequently innovative new methods of adapting and utilisation of existing material have to be explored with extreme expedience.

# 7 Conclusion and recommendations

The demand for Welsh softwood is currently strong, with there being the need to transport material from other areas in the UK to meet the current demands of Welsh sawmills. This corresponds with the pan-European trend. Whilst the UK only produces approximately ¼ of its total sawn wood requirement, 88% of homegrown material is currently earmarked for that market. Recent trends have seen the amount of homegrown material used increase, and this is espected to continue. Whilst the UK will never reach self-sufficiency, Europe as a whole is expected to achieve this in the near future.

Typically the supply of softwood in Wales is split between 68% Forestry Commission / 32% Private ownership. This ratio is not expected to fluctuate greatly.

The demand for softwood is expected to continue, or even increase. The latter is seen as more likely due to increasing demand for raw materials for CHP plants across the United Kingdom. There is already a significant demand for material for the CHP plant at Shotton and a further two of these plants are under development in South Wales, with more likely in the foreseeable future. One of the benefits of such plants is the ability to use brash.

Welsh sawmills mainly specialise in C16 graded material. There may exist an option to select material in order to achieve a C24 class, though this would be at the reduction of quality within the C16 material. Observations from the timber frame industry suggested that there would be a willingness to use Welsh C16 for construction programmes, providing sufficient supply could be guaranteed. However some companies indicated that architects / specifiers insisted in the sole use of imported timber (usually graded to C24). It was also noted that the C16 currently available (in 47mm width) did not meet the requirements of the timber frame manufacturers (who required 38mm). This would suggest a possible market opportunity, provided a sawmill was willing to change cutting patterns. Welsh sawmills currently achieve excellent market prices for C16 material, whilst other sawmills who do not stress grade are observing strong markets for softwoods for use in markets such as fencing and cladding.

There may well exist the opportunity to upgrade Welsh softwood to achieve a technologically superior product. However it is necessary to decide if this is necessary. Is the current market seen as providing sufficient income for the industry? The markets already exist, and moving away from these markets could be seen as a financial risk. In the short term there may be significant financial gains, but over a longer term will these new markets remain as constant as those already on the books.

However the option does exist for technological advancement, to produce superior products. This report has outlined several possibilities, though many more opportunities exist. The major disadvantage of new processing methods will be the initial financial outlay. It will be necessary to carefully assess both the advantages and disadvantages for any new method.

The accompanying report of the questionnaire to timber frame manufacturers suggested a willingness to use Welsh grown material, should it be available. Greater restrictions in carbon footprints might herald new opportunities for Welsh grown softwoods, especially when considering localised niche markets. Lessons learnt from recent work into Welsh hardwoods may prove useful in determining new options for Welsh softwood.

In order for many of the aspects covered in this report to be considered, further work will be required. To date only the concepts have been demonstrated, fully marketable products are still some way from fruition. The willingness of Welsh companies has been determined, and it would be prudent to develop programmes of work capable of helping industry gain access to local material meeting their needs.

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## Appendix A – Graphical representation of European import and export levels

The following figures are provided to provide graphical evidence of the European timber industry as reported by UNECE FAO in 2002:

A1: Imports of Sawn timber (1000 $m^3$) within Europe in 2002

A2: Exports of Sawn timber (1000 $m^3$) within Europe in 2002

A3: Relationship between product and international trade of sawn timber (1000 $m^3$) across Europe in 2002

A4: Apparent consumption of sawn timber across Europe in 2002 (1000 $m^3$)

A5: Self-sufficiency indicators for European countries in 2002.

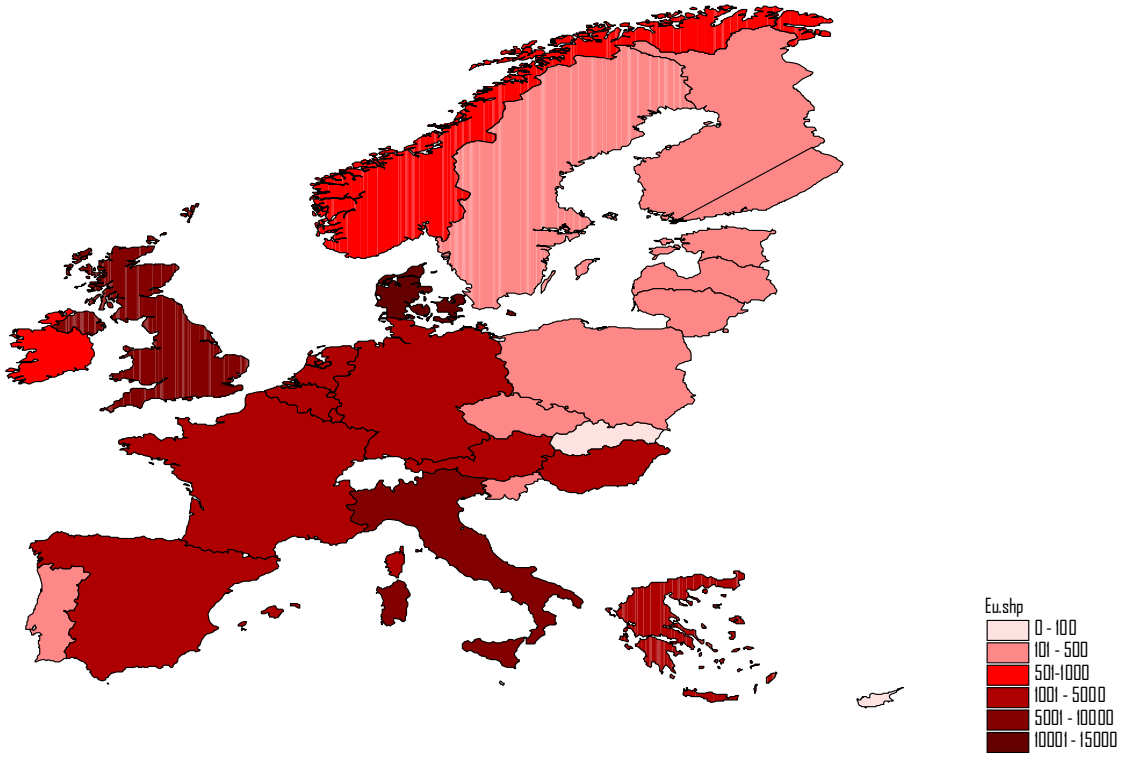

Figure A1: Imports of Sawn timber (1000 $m^3$) within Europe in 2002

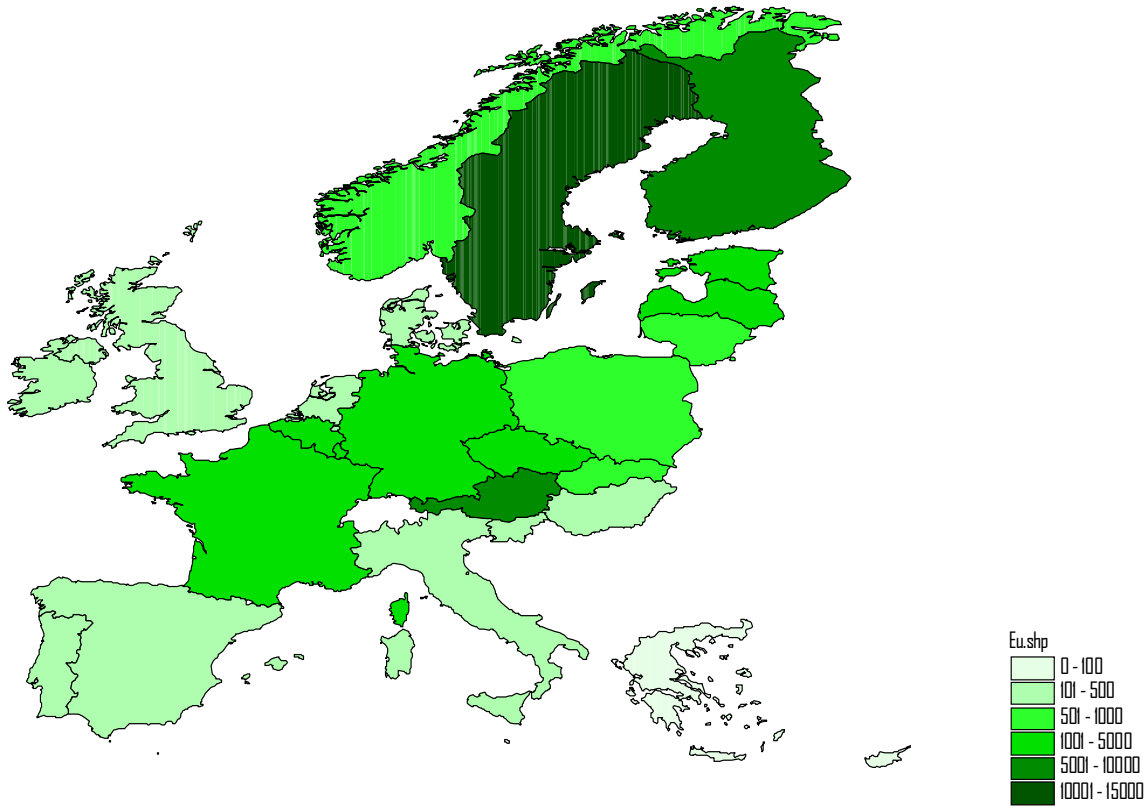


Figure A2: Exports of Sawn timber (1000 $m^3$) within Europe in 2002

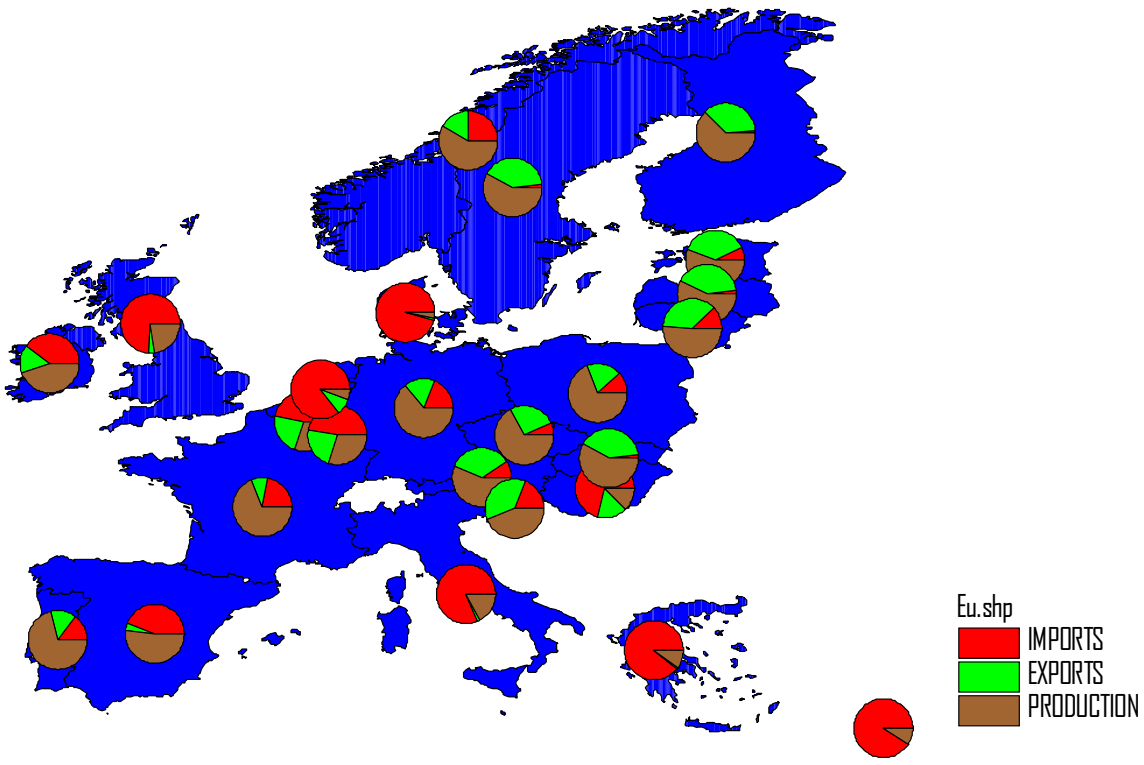


Figure 3: Relationship between product and international trade of sawn timber (1000 $m^3$) across Europe in 2002

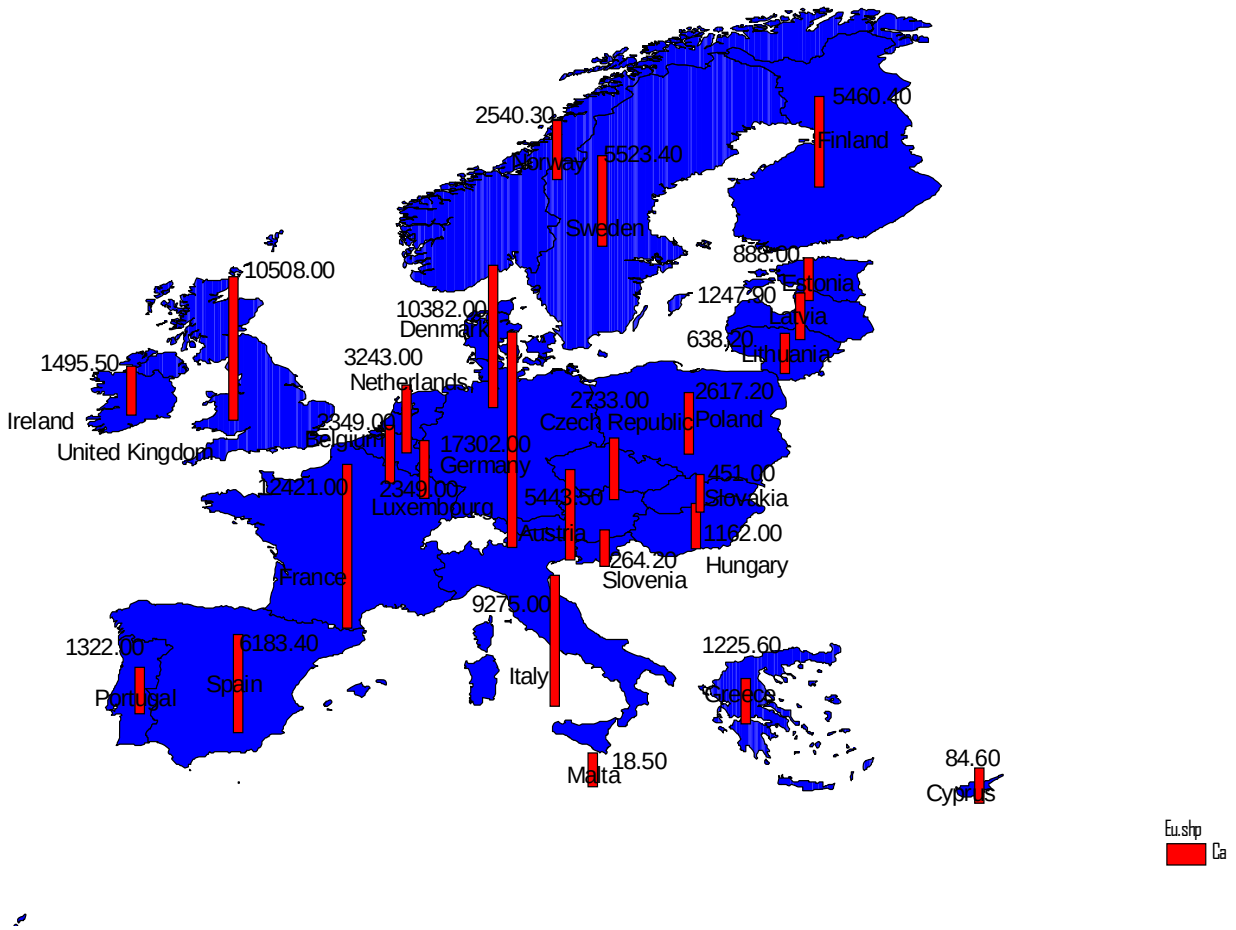


Figure A4: Apparent consumption of sawn timber across Europe in 2002 (1000 $m^3$)

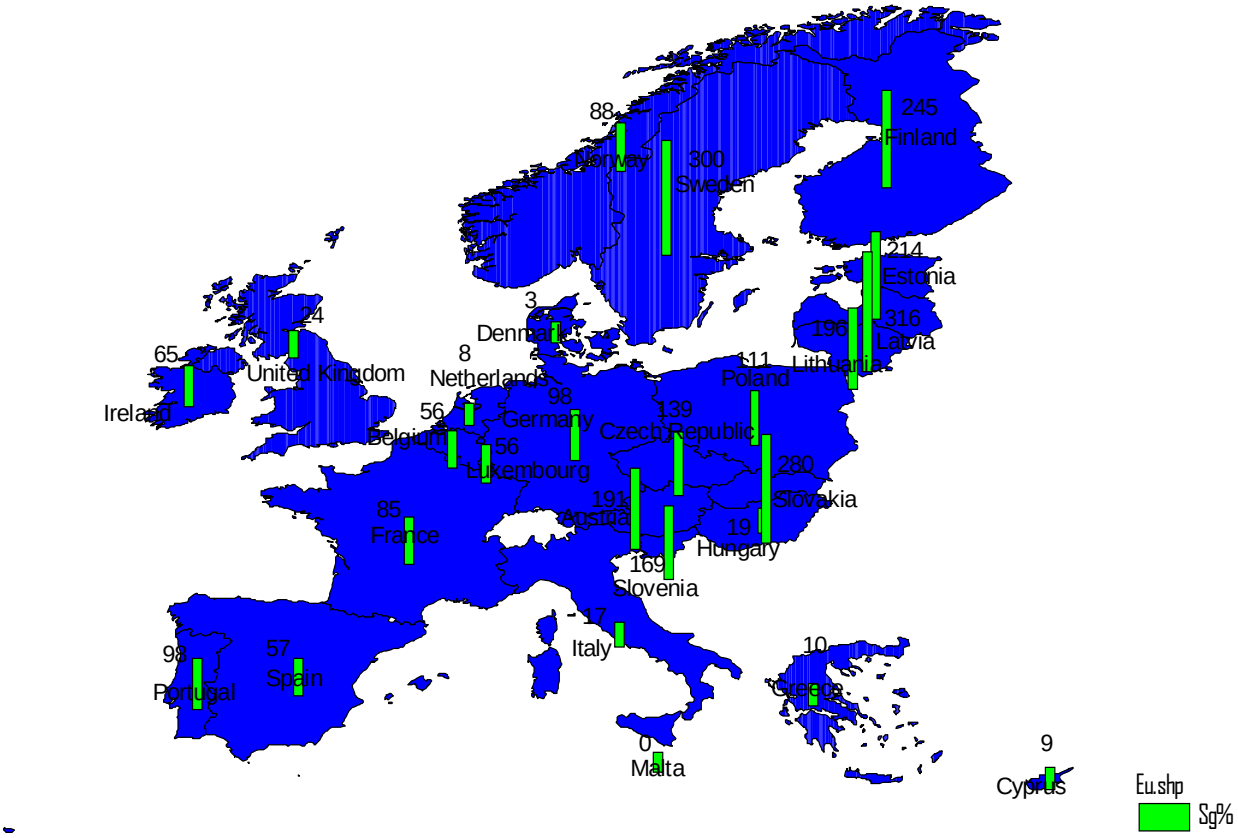


Figure A5: Self-sufficiency indicators for European countries in 2002.

## Appendix B – Customer satisfaction form

In order for BRE to critically assess its delivery, we kindly request that you complete the following customer satisfaction form and return it as directed. It is through the feedback of our valued clients that any necessary changes can be made for future delivery.

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## Customer Satisfaction Survey

Please assist us in improving our service to you by giving us your feedback. All replies are treated as commercial in confidence and should be returned to Corporate Marketing at BRE.

PLEASE RETURN this form either by e-mail to marketing@bre.co.uk or by fax on +44(0)1923 664790

| | |
|---|---|
| Customer: | |
| Customer Contact: | |
| Project Title: | |
| BRE Project number: | |
| BRE Centre: | |
| Project Manager: | |
| Completion/Milestone Date: | |

(Please mark one box for each question)

| | Unsatisfactory | Needs Improvement | Meets Requirements | Exceeds Requirements | Not Applicable |
|---|---|---|---|---|---|
| **TECHNICAL COMPETENCE** | | | | | |
| How well did we meet the agreed technical programme? | ☐ | ☐ | ☐ | ☐ | ☐ |
| How do you rate our technical competency? | ☐ | ☐ | ☐ | ☐ | ☐ |
| **COMMERCIAL AWARENESS** | | | | | |
| Did we understand and meet all your needs? | ☐ | ☐ | ☐ | ☐ | ☐ |
| How well did we comply with the project brief? | ☐ | ☐ | ☐ | ☐ | ☐ |
| Did we provide value for money? | ☐ | ☐ | ☐ | ☐ | ☐ |
| **DELIVERY** | | | | | |
| How would you assess the quality of our delivery? | ☐ | ☐ | ☐ | ☐ | ☐ |
| How would you rate the timeliness of our delivery? | ☐ | ☐ | ☐ | ☐ | ☐ |
| How would you rate the clarity of our written reports? | ☐ | ☐ | ☐ | ☐ | ☐ |

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| PERSONAL SERVICE | Unsatisfactory | Needs Improvement | Meets Requirements | Exceeds Requirements | Not Applicable |
|---|---|---|---|---|---|
| How would you assess our project administration? | ☐ | ☐ | ☐ | ☐ | ☐ |
| How effective was our communication with you? | ☐ | ☐ | ☐ | ☐ | ☐ |
| How do you rate the professionalism of our staff? | ☐ | ☐ | ☐ | ☐ | ☐ |
| **GENERAL** | | | | | |
| As a whole did our service meet your expectations? | ☐ | ☐ | ☐ | ☐ | ☐ |
| Would you use our services in the future? | ☐ | ☐ | ☐ | ☐ | ☐ |
| Would you recommend our services to other clients? | ☐ | ☐ | ☐ | ☐ | ☐ |

We would appreciate your comments on how we could improve our service to you

| | |
|---|---|
| Completed by: | |
| Name: | |
| Email: | |
| Telephone: | |
| Date: | |