

Introduction

The range review assessment process

Range reviews are designed to provide an overview of a certain product or group of products that are available on the market. Determining what makes a product 'sustainable' is never easy or straight forward. For some products it may be the ability to biodegrade that is considered important; for others it could be the operational performance or durability. The range review process helps to put product sustainability into context and to prioritise those decisions and factors that are the most important to consider. Range reviews use the 10 One Planet principles to provide a framework for considering sustainability; these principles have emerged - and been tested and refined – through extensive project work throughout the world.

Kitchens

This review concentrates on the structural elements of kitchen design such as the worktops and carcasses. Electrical items such as dishwashers, refrigerators and freezers are excluded from this range review however these products should not be neglected in sustainable design and product selection.

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One Planet Products was launched by BioRegional Development Group, an entrepreneurial, independent environmental organisation that develops award winning, commercially viable products and services to help enable One Planet Living – living within our fair share of the Earth's resources. For further information, please visit www.bioregional.com

Zero carbon	making buildings more energy efficient and delivering all energy with renewable technologies
Zero waste	reducing waste arisings, reusing where possible, and ultimately to send zero waste to landfill
Sustainable transport	encouraging low carbon modes of transport to reduce emissions, reducing the need to travel
Sustainable materials	using sustainable products that have a low embodied energy
Local and sustainable food	choosing low impact, local, seasonal and organic diets and reducing food waste
Sustainable water	using water more efficiently in buildings and in the products we buy; tackling local flooding and water course pollution
Natural habitats and wildlife	protecting and expanding old habitats and creating new space for wildlife
Culture and heritage	reviving local identity and wisdom; support for, and participation in, the arts
Equity, fair trade and local economy	inclusive, empowering workplaces with equitable pay; support for local communities and fair trade
Health and happiness	encouraging active, sociable, meaningful lives to promote good health and well being



Key Environmental Indicators

Several of the One Planet principles are relevant to the product selection of kitchen worktops, ranging from **Local and Sustainable Materials**, to **Sustainable Transport**, **Waste**, **Natural Habitats and Wildlife**, and **Equity and Fair Trade**. Kitchen worktops can be made from various materials, and each one has different environmental impacts that may be minimised through the supply chain. A majority of kitchen worktops are made from chipboard / particleboard that are coated with a plastic surface. The standard width for worktops is 600 mm and this is considered appropriate for most kitchen configurations.

For comparison, the common materials that worktops are made from are outlined below, together with the key environmental indicators for each material. A common indicator to all material comparisons is an assessment of embodied carbon and energy. Transport distance is typically the secondary indicator because worktops are heavy items and therefore there are greater environmental impacts associated with large transport distances.

Worktop Material	Embodied CO ₂	Primary consideration	Secondary consideration	Notes
Timber with laminate	BioRegional estimate: 475 kg / tonne This figure includes the CO ₂ emissions associated with production and transportation but not sequestration. Please see Appendix 1 for further information.	Timber certification Forest Stewardship Council (FSC) certification is preferable. Other certification schemes also exist such as PEFC. Please see Appendix 2 for further information.	Transport distance Sourcing timber from the UK is preferable as it reduces the transport emissions associated with the product.	Laminate is a vague term since it simply refers to two materials bonded together. In kitchens, high pressure laminate (HPL) is typically used and this consists of chipboard bonded to a layer of resin, paper and plastic. Melamine is typically used and a melamine resin is produced by combining melamine with formaldehyde.
Solid timber veneer and chipboard	BioRegional estimate: 475 kg / tonne This figure includes the CO ₂ emissions associated with production and transportation but not sequestration. Please see Appendix 1 for further information.	Timber certification Forest Stewardship Council (FSC) certification is preferable. Other certification schemes also exist such as PEFC. Please see Appendix 2 for further information.	Transport distance Sourcing timber from the UK is preferable as it reduces the transport emissions associated with the product.	This involves a timber veneer glued to the surface of a core panel that is typically made from particleboard / chipboard.

Worktop Material	Embodied CO ₂	Primary consideration	Secondary consideration	Notes
Stainless Steel	Embodied carbon¹: 615 kg / tonne	Recycled content As stainless steel has high embodied energy a high proportion of recycled content is environmentally preferable. On average stainless steel contains 42.3% recycled content ³ but WRAP recommends that specifiers target a level of 75% recycled content in the products that they purchase. ⁴	Transport distance Sourcing steel from the UK or surrounding countries is usually preferable as it can reduce the transport emissions associated with the product.	Stainless steel is not commonly used in domestic applications. While it is hardwearing and remains hygienic it can be difficult to keep it looking clean. Stainless steel also has a high level of embodied CO ₂ .
Granite	Embodied carbon: Local granite: 317 kg / tonne Imported : 747 kg / tonne	Extraction impact A significant amount of waste can be generated during excavation and fabrication processes. Some estimates suggest that 45-80% of granite is wasted during manufacture and processing. ⁵ In addition all of the surface material that needs to be extracted to get to the stone will be wasted as well. Please see Appendix 2 for more information.	Transport distance Sourcing granite locally can reduce the transport emissions associated with the product. However, while a small amount of granite is currently mined in the UK the majority is imported in from countries such as Italy, Turkey, China, Mexico and Australia. Please see Appendix 2 for more information.	Granite worktops are expensive and are unlikely to be specified in large scale housing developments.
Glass	Embodied carbon²: General glass: 610 kg / tonne Recycled glass: 310 kg / tonne	Recycled content Recycled glass saves on raw materials and energy. Worktops can be manufactured without using any virgin glass.	Transport distance Glass is a heavy product and therefore should be sourced as locally as possible to reduce transport emissions.	Glass is not commonly used in kitchen worktop design.
Plastics	Embodied carbon²: Virgin plastic: 2,877 kg / tonne Recycled plastic: 1,215 kg / tonne	Recycled content Recycled plastic saves on raw materials and energy. The recycled content of plastic worktops ranges from nothing at all through to 100% recycled content. Be sure to check that the recycled content is post-consumer plastic rather than pre-consumer waste which is essentially virgin material in disguise.	Transport distance As with the other materials it is more environmentally preferable to source plastic as locally as possible to minimise transport emissions.	There are a variety of plastic based worktops on the market. Corian is a solid surface material manufactured by DuPont made from 1/3 high quality virgin acrylic ingredients and 2/3 natural minerals. There are a few plastic worktops that incorporate an element of recycled content. Durat, for example, manufacture worktops using 30% post consumer recycled material while most of the plastic in Smile Plastic's range is made using 100% post consumer waste.

1. University of Bath. 2008. Inventory of Carbon and Energy. [Online]. Available at: www.bath.ac.uk/mech-eng/ser/embodied. [Accessed 23 Jul 09].

2. Yorkshire Forward. 2008. Resource Efficiency and Greenhouse Gas Emissions. Yorkshire Forward : York.

3. Calkins, M. 2009. Materials for Sustainable Sites. Referencing the Institute of Stainless Steel Forum. Hoboken, New Jersey : John Wiley & Sons, P.340.

4. WRAP. 2008. Standard, Good and Best Tables. [Online]. Available at www.wrap.org.uk. [Accessed 25 Jan 10].

5. Demkin, J. ed. 1998. Material Report 04450 Stone Veneer. In Environmental Resource Guide. New York : John Wiley & Sons, p. 17.

Specification Guidance

In this work, the **embodied carbon and energy** of the common materials used in kitchen design are assessed, there is also consideration of material lifetime, waste generated during manufacture and equity and fair trade. When considering equity and fair trade, companies may try to ensure materials are ethically sourced, however it is appreciated that traceability throughout the whole supply chain is often extremely difficult.

Standards for kitchen furniture

BS 6222-2 for structural performance of domestic kitchen. This standard has two grades depending upon the level of care exercised by the user. Grade G is for domestic situations where users are expected to exercise care and Grade H is for heavy use where users are not expected to exercise care.

BS 6222-3 for durability and adhesion of surface finishes. This standard investigates the integrity of the surface against impact, scratching, wet and dry heat as well as resistance to a range of chemicals and liquids. Having a high performance surface finish is important to protect the underlying material.

BS EN 312 particle board specification.



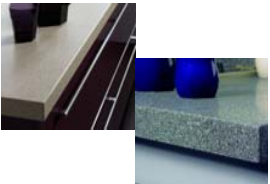
Useful Links

[Furniture Industry Research Association \(FIRA\). Available at: http://www.fira.co.uk/](http://www.fira.co.uk/)


The table below gives a selection of the range of products currently on the market. There is a focus on products that perform well in terms of sustainability, however the range also covers lower performing products to provide specifiers with a feel for the other products out there, together with the associated costs.

Quoted prices are a rough guide as price variations differ depending on the specifications e.g. quantity, shape etc and therefore there might be up to a 50% difference.



The following table represents a sample of the types of worktops that are available on the market. There similar alternatives are also available.

TIMBER WITH LAMINATE						
Company	Product	Primary indicator: Timber certification	Secondary indicator: Transport distance	Price (per m ²)	Notes	
<u>Bushboard</u>	Prima 	PEFC Certified Chipboard	Manufactured: Wellingborough, Northamptonshire Materials source: France	0km 935km	£40-60	50 different decors available. Chipboard with a melamine finish. Chipboard is from 100% virgin pine forest in France (a back up source from the UK is sometimes used; 30% recycled timber from local factory by-product, or Kilder Forest, Hexam).
<u>Duropol</u>	Quandra 	PEFC Certified Chipboard	Manufactured: Germany Materials source: Germany	817 km 817 km	£50-75	61 different decors available. Chipboard with a melamine finish. All materials carry PEFC certification 'guaranteeing properly environmentally managed and sustainable sources'.
<u>Bushboard</u>	Encore 	PEFC Certified Chipboard	Manufactured: Wellingborough, Northamptonshire Materials source: France	0km 935km	£175-£225	11 different decors available. Chipboard with 5mm 'solid surface' methyl methacrylate finish. Chipboard is from 100% virgin pine forest in France (a back up source from the UK is sometimes used; 30% recycled timber from local factory by-product, or Kilder Forest, Hexam).


TIMBER WITH PVC WORKTOPS

Company	Product	Primary indicator: Timber certification	Secondary indicator: Transport distance	Price (per m ²)	Notes
Formica	Axiom 	International Tropical Timber Trade Organization (ITTO) ITTO endorsement is not as robust as FSC or PEFC certification. Please check Appendix 2 for more details.	Manufactured: 0 km North-East England Materials source: Denmark 853 km	£60-£75	79 different decors available. Chipboard with PVC square edge. The 40mm thick Axiom Solid Surfacing worktop has a 6mm thick composite top layer, with front and short edges of the same material. This is bonded to high density moisture resistant particle board core which provides structural strength.



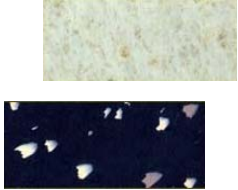

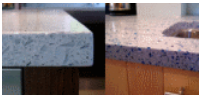
SOLID TIMBER WORKTOPS

Company	Product	Primary indicator: Timber certification	Secondary indicator: Transport distance	Price (per m ²)	Notes
Formica	Axiom Shape 	International Tropical Timber Trade Organization (ITTO) ITTO endorsement is not as robust as FSC or PEFC certification. Please check Appendix 2 for more details.	Manufactured: 0 km North-East England Materials source: 853 km Denmark	£125-£175	6 different decors available. Chipboard with 6mm solid surface. The Solid Wood worktops are made from Iroko, European Walnut, European Oak and Light Steamed Beach and are made from 6mm solid surface material bonded to 34mm chipboard.
Sheridan	Apollo Natural Surface Wood 	FSC certified solid timber	Manufactured: 1,434 km Italy Materials source: Various including Slovakia, Poland, Africa and South America.	Unable to obtain. Our estimate £175-£300	13 different species available. Comes in 40mm thicknesses as standard but 27mm and 60mm available for some species. These worktops are made from solid hardwood timber. Species include Bamboo, Cherry, Beech, Walnut, Iroko, Maple, Oak, Sapelli, Ash, Teak, Tiger Walnut, Wenge and Zebrano.

GRANITE WORKTOPS

Company	Product	Primary indicator: Embodied carbon / energy	Secondary indicator: Transport distance	Price (per m ²)	Notes
Diapol	Granite worktops 	Local : 25 kg CO ₂ / m ² Imported : 60 kg CO ₂ / m ²	Manufactured: Estonia. 1,867 km Materiala source: Granite material comes from all over the world, including India,Brazil and Finland.	£120 - 245	Available in 40 different 'shades' of granite. Manufactured out of quarried granite. There are a wide range of environmental impacts from granite extraction ranging across waste, natural habitats and wildlife, and equity and fair trade. Please see Appendix 1 for further information.

OTHER MATERIALS WORKTOPS

Company	Product	Primary indicator: Recycled Content	Secondary indicator: Transport distance	Price (per m ²)	Notes
<u>Durat</u>	Durat Plastic 	30% post consumer recycled plastic.	Manufactured: Finland 1,826 km Materials source: Sweden & Finland 1,826 km	£150-£250	Durat work surfaces are made from 30% post-consumer waste plastic that would otherwise be sent to landfill and is 100% recyclable at end of life. All internal factory offcuts are recycled to form new products. The material is guaranteed for 15 years.
<u>PaperStone</u>	Original 	100% post-consumer recycled waste.	Manufactured: UK. 0km Materials source: USA. 7,200 km	£75-£250	12 different decors available. Paperstone is made from FSC certified 100% post-consumer recycled paper and cardboard waste. The company also sell a single worktop that is made from FSC certified virgin timber fibres. The product has been tested and certified as non-detectable for formaldehyde. It is a composite material made from post-consumer waste, recycled paper and proprietary, petroleum-free, phenolic resins.
<u>Smile Plastics</u>	Recycled Worktops 	100% post-consumer recycled waste.	Manufactured: UK. 0km Materials source: UK. 0 km	£180-£225	Every worktop is bespoke. Common styles used for kitchen worktops include Smile's 'Charcoal' and 'Yogurt Pot' ranges. Smile plastic use flakes of post-consumer recycled material melted at 180°C and compressed under pressure to create their worktop range.
<u>GlassECO</u>	GlassECO Original 	85% of the product is made from post consumer recycled glass with a recycled stop board underneath the worktops that brings the total recycled content up to 95%	Manufactured: Surrey, UK. 0 km Materials source: Surrey, UK. 0 km	£270	Standard range of 30 worktops. Bespoke finishes available using one of 4 basic resin colours. GLASeco worktops require minimal energy to manufacture. Rather than being melted the glass is broken down into small chunks that are bound together using a low toxicity resin made from recycled plastic bottles. GLASeco collect glass from local businesses (within a 10 mile radius) that do not have existing glass recycling schemes. All the glass used would otherwise have gone to landfill.
<u>Eight Inch</u>	Resilica 	85% of the product is made from post consumer recycled glass. A solvent free resin is used to bind the glass together.	Manufactured: Brighton, UK. 0 km Materials source: Brighton, UK. 0 km	£350	Every worktop is bespoke. The standard Resilica resin is available in 11 different colours. Glass fragments variable and bespoke. No heating is required in the manufacturing process meaning that the embodied energy requirement is relatively low. Manufacturing process is very similar to that of GlassECO. The glass component is sourced from 100% post consumer recycled material.

*Transport distances are calculated distances between the centre of each country, using from www.convertunits.com/distance.

** See Appendix 2 for notes on timber certification.

One Planet Solution

For kitchen work tops the most environmentally preferable solution will usually involve adherence to the waste hierarchy. Reclaimed kitchen worktops, for example, generally have the lowest environmental impact provided that they are not transported from too far a distance. Worktops that are made from a high proportion of post consumer recycled material also offer a good solution. Note that FSC certified worktops with the 'FSC recycled' logo would meet this requirement (see Appendix 2). The least preferable solution will usually involve using a material that is completely made from virgin material.



One Planet Products aim to provide accurate and up to date information. If you see any missing or out of date information, or would like to see a particular manufacturer or product listed, please get in touch by email: enquires@oneplanetproducts.com

Specification guidance: Doors, drawer fronts and carcasses

Key environmental indicator: Materials

Similarly to kitchen worktops, several One Planet principles are relevant to the product selection of the kitchen furniture of doors, drawers and carcasses, ranging from **Local and Sustainable Materials**, to **Sustainable Transport**, **Waste**, **Natural Habitats and Wildlife**, and **Equity and Fair Trade**.

Common materials

Doors and drawer fronts generally come in three material types: solid timber, PVC coated medium density fibreboard (MDF), and melamine coated particleboard. The embodied energy of a typical kitchen door is typically in the range of 90 – 240 MJ / m², with the embodied carbon in the range of 6 – 15 kg CO₂ / m². Stainless steel and glass doors are also sometimes used, however because of the higher embodied carbon and energy in these products, together with other environmental impacts, One Planet Products does not advocate that these materials are used. A recommended One Planet Solution is outlined below, followed by an overview of the environmental impacts of the different door and drawer front materials. An example product range has not been produced for doors and drawer fronts and the focus is on specification guidance.

Carcasses are typically made from melamine coated chipboard however alternative types of timber may be used that have low quantities of adhesive and high levels of recycled content.

Embodied impacts: This is considered by comparing embodied carbon values, the meeting of basic material expectations, and the transportation distance considered by identifying the material source and country of manufacture. The table below compares the embodied carbon of the different materials, with the density accounted for so that the embodied carbon per m² is approximated. It should be noted that this is an approximate calculation but gives some idea of the relative environmental impacts between the materials.

Table 1 Typical embodied carbon and energy values for (Embodied carbon data from University of Bath 2008, and density data from <http://www.simetric.co.uk>).

Material	Embodied carbon (kg CO ₂ / kg)	Typical density (kg / m ³)	Embodied carbon per m ² (kg CO ₂ / m ²)
Stainless steel (assume 0.25mm thick hollow doors)	1.69	7,750	23.9
MDF (18.5 mm)	0.59 (+/- 30%)	700	7.6
Veneer particle board	1.24 (+/- 40%)	650	14.9
Glass (assume 5mm thick)	0.85 (+/- 30%)	2,600	11.0 – 16.4

* This value does not include the effect of sequestration and this value can be highly variable. See appendix 2 for further details

Due to the high degree of uncertainty in embodied carbon data that is available, it is not possible to fully examine the embodied impacts of these products within the scope of this research. However, using the One Planet principles it is possible to explore other aspects of sustainability involved in specifying materials. Specifiers should refer to the information presented in the worktops section to understand the different environmental impacts around the material selection.



One Planet Solution

As with the worktops the most environmentally preferable solution would be to use reclaimed kitchen units rather than new ones made out of recycled or virgin materials. For general applications One Planet Products recommends the use of sustainably sourced timber materials, ideally meeting either the 100% FSC or FSC Recycled criteria. Specifiers should also ensure that the product's end of life options include reuse and recycling. This can be achieved by choosing products that use mechanical, rather than glue based, fixings and ones that have a recyclable coating.



Using Reclaimed Worktops

Direct substitution of new virgin material for reclaimed material can radically reduce the environmental impact of a kitchen unit or worktop. This is because reclamation removes the need to extract new raw materials and dramatically reduces the need for processing and manufacture. Transportation is usually still required but often at a reduced level because reclaimed materials tend to be source more locally than new materials.

A 'reclaimed material' is any material that has been used before either in a building, in temporary works or for other uses and is then re-used as a construction material without reprocessing. Reclaimed materials may be adapted and cut to size, cleaned up and refabricated but they are essentially being re-used in their original form.



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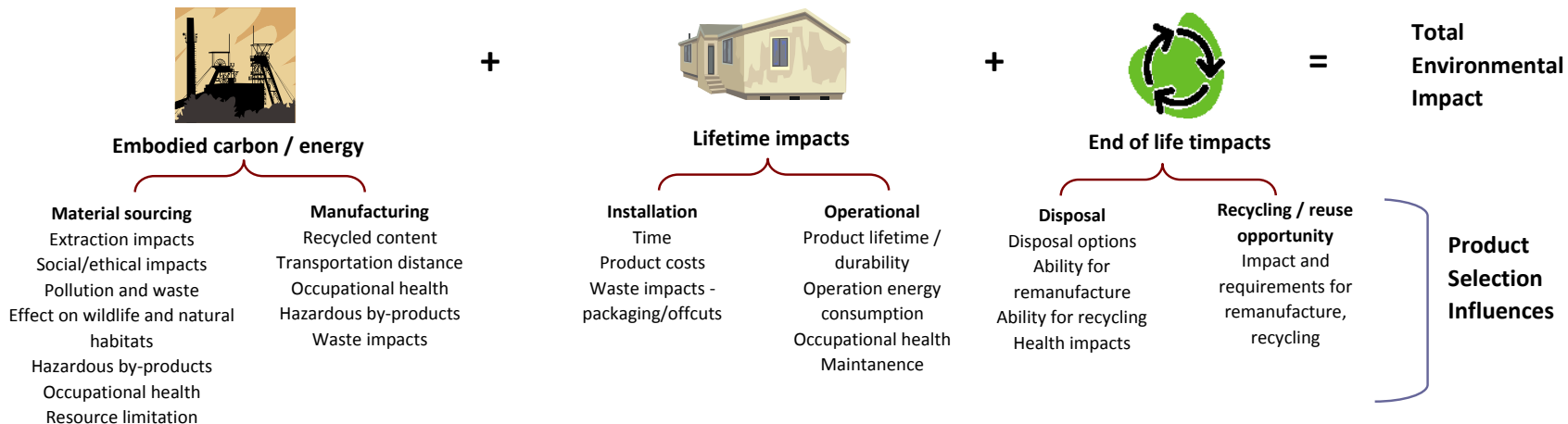
Appendix 1: Methodology

Understanding the environmental impact of a product involves an appreciation of the impacts in a product’s lifecycle all the way from the sourcing of the raw materials, through to manufacturer, operation and its end-of-life options. As shown below, products have **embodied impacts** arising from the sourcing, manufacture and transportation. The chosen product will also have **operational impacts** and perhaps impacts from **maintenance**. The product’s **lifetime** is also important and characteristics such as durability, resistance to erosion and fatigue should be considered in the design. Finally there are **end-of-life considerations** such as whether the materials that form the product can be reused or recycled.

One way to understand these impacts is using a Life Cycle Assessment (LCA) approach and the procedure for this is part of the ISO 14000 environmental management standards: in ISO 14040:2006 and 14044:2006. Full LCAs are highly detailed and consequently take a significant amount of time to complete for a single product, often in the region of 180 days each. Therefore it is not particularly feasible to provide a quick and easy comparison of environmental performances across large numbers of products. Additionally, it has been argued that LCA alone is not a sufficient tool for achieving an absolute reduction of environmental impact as it does not tackle social and economic impacts that might occur as a result of selecting a product (these are often called rebound effects) (Hofstetter, 2009). Therefore the review process couples the lifecycle considerations outlined below and considers them in conjunction with the 10 One Planet principles outlined in the introduction; this is an established framework for considering sustainability holistically, considering not just embodied carbon and resource efficiency, but also issues around equity and fair-trade, and health and happiness.

Range reviews aim to make it easy to quickly identify the most appropriate environmental indicators to consider so that effective comparisons across products can be made. The products in the range review are not an exhaustive list of products available, rather a selected sample of the best type of products that are available, together with a few examples of less preferable alternatives.

Some of the main considerations at each stage of a product’s lifecycle are given below. Range reviews use these ideas together with the 10 One Planet principles to decide what the main indicators for a product are. We have called these the ‘key environmental indicators’. The approach for deciding which key indicators to use relies, in part, on qualitative judgements, drawing from expertise in materials and footprinting, peer-reviewed journal papers and other key data sources. Where these judgements have been made we will always provide a clear indication of our rationale for why we came to that decision.



Appendix 2: Technical notes on materials

Some further technical details and issues related to sustainability for common materials in this range review are considered here.

Timber

Timber certification

Trees are vital in helping regulate the weather and atmosphere in which we live, they also support whole eco-systems and help prevent erosion of the soil. Humans have had a long history of using timber for firewood and construction. With the increases in global trade, population and changes in culture over the last 100 years, we have to ensure we do not overharvest from the world's forests and therefore the right certification schemes should be used to ensure timber is sourced sustainably.

There are four main timber accreditation schemes; the Forest Stewardship Council (FSC), the Canadian Standards Association (CSA), the Sustainable Forest Initiative (SFI) and the Programme for the Endorsement of Forest Certification (PEFC). FSC is the dominant certification body within the UK while most other European timber is accredited by the PEFC. Some manufacturers only source their timber from the International Tropical Timber Organization (ITTO), for more information on this please see the ITTO section below.

Recommendations: BioRegional believe that locally sourced and FSC certified timber is most preferable option, and European PEFC and FSC is acceptable. FSC or PEFC timber sourced from within Europe is generally of a high quality. For outside of Europe specifiers should always try to stick to FSC due to a number of criticisms raised against national PEFC schemes. These criticisms include PEFC not being a prescriptive or consistent standard, and not requiring sufficient stakeholder agreement or sufficient protection of biodiversity values.

FSC Certification: Guide to specifiers

The **Forestry Stewardship Council (FSC) Certification scheme** is one of the world's largest schemes that promote responsible management of forests. It is supported by most environmental groups across the world and is recommended in range reviews as a preferable source of timber when appropriate for a product. From time-to-time the FSC scheme has come under some criticism from certain groups (FSC Watch, 2009) for not being transparent and robust enough. Although this is appreciated and should be recognised, it should not deter a specifier from choosing FSC certified timber as it is still the most reliable and robust timber certification scheme that exists.

There are four types of label:



100%: Products come only from well-managed forests that have met FSC's social and environmental standards.

Recycled: support the re-use of forest resources which helps to reduce the pressure on natural forests.

Mixed sources: Allows manufacturers to provide FSC labeled products that include a minimum of 10% FSC certified material, with the remaining material complying with the FSC Controlled Wood standard or being recycled.

Recommendations:

- **Product specifiers should specifically request they want an FSC certified product.** This is because some manufacturers only use certified timber across certain products in their range, and do not make this clear in their literature.
- **Specifiers should request to see the FSC chain of custody certification.** In addition to the logo the certification ensures the product is fully FSC certified. FSC has different types of certification and products should have the FSC chain of custody certification; this certification ensures a manufacturer has tracked FSC certified material through the production process - from the forest to the consumer, including all successive stages of processing, transformation, manufacturing and distribution.
- **Specifiers should aim to use 100% certified or Recycled FSC certified products.** Mixed source FSC certified materials can contain as little as 10% FSC certified material meaning that the vast majority of the product is made from uncertified forms of timber.

The International Tropical Timber Organization (ITTO)

The International Tropical Timber Organization (ITTO) develops internationally agreed policy documents to promote sustainable forest management and forest conservation. It also assists tropical member countries to adapt such policies, and collects, analyses and disseminates data on the production and trade of tropical timber. Its members represent about 80% of the world's tropical forests and 90% of the global tropical timber trade.

Manufacturers sometimes claim that using timber suppliers that are members of this organisation means their timber is sustainably sourced; however it is not a guarantee of sustainability and is different to the more robust requirements set out by the FSC or PEFC schemes. For more information please see the ITTO website at www.itto.int.

Types of timber

There are three types of boarding made from ground timber, these are fibreboard, chipboard and cork sheeting.

Fibreboard

Fibreboard is produced in porous, semi-hard and hard variations. For most types of fibreboard, glue is required during the manufacture.

Medium Density Fibreboard

Medium density fibreboard (MDF) is a wood composite material that is often used in furniture. It is typically composed of 82% virgin wood fibre (predominantly softwood) (Wood Panel Industries Federation, 2009) and manufactured using a dry process that involves bonding the wood with a synthetic resin that is usually formaldehyde-based. The amount of adhesive required is typically in the region of 4-10% by weight (Berge, 2009).

Chipboard and Orientated Strand Board

Chipboard is made from shredded and ground timber that is dried before glue is applied, in the region of 10% by weight. Orientated strand board (OSB) is a type of chipboard made from strands of shredded timber, with 3-6% adhesive required.

Plywood

Plywood can be produced from many different types of timber. It is made from three or more very thin wood sheets laminated together with an adhesive. The adhesive is usually urea or phenol glue in a proportion of about 2% by weight; animal based and soya glues are considered to give good results (Berge 2009). Each layer of wood is orientated with its grain at right angles to the adjacent layer, this helps reduce shrinkage and improves the strength of the plywood.

Embodied CO₂ in timber

There is much complexity in assessing the embodied carbon and considering carbon sequestration of timber. Uncertainties are in the region of \pm 30-40% (ICE, 2009) and the carbon impact may depend on the methods of timber sourcing by the manufacturer. For example, some suppliers believe that using timber is carbon positive since if sourced sustainably, then its use is actually helping to sequester carbon over a long period of time.

Using a combination of figures provided by the BRE and Bath University the total amount of CO₂ 'absorbed', or rather sequestered by a tree equates to 1405 kg CO₂ per tonne of hardwood and 1255 kg CO₂ per tonne of softwood. The energy involved in processing and transporting timber will typically emit approximately 475 kg CO₂ which gives an overall net benefit of 780 kg CO₂ for softwoods (1255 – 475 kg CO₂) and 930 kg CO₂ for hardwoods (1405 – 475 kg CO₂).

Granite

Globally the mining industry is one of the least regulated industries of any kind (Calkins, 2009). As a result, some quarry sites have been abandoned leaving huge waste piles, with minimal control over toxic wastes and little attempt to restore the site to its pre-mining habitat. The quarry debris heaps, known as tailings, can leach minerals into local water courses thus leading to the pollution of rivers and damaging the ecosystems. Like most dimension stone, granite, needs to be sawed into the right shapes and sizes prior to dispatch. Water, sometimes in large quantities, will be used to cool the processing saws. This increases water demand and also dust and particulates into the local water courses.

Only a small amount of granite is mined within the UK with most being imported from countries such as Italy, Turkey, China, Mexico and Australia. In some of the developing countries where granite is extracted there are poor labour rights including lack of basic Health and Safety legislation, low pay, child labour and so on. Where legislation is unsatisfactory the human health impacts of mining can be quite severe. For example, in China, between January 2001 to October 2004, there were 188 accidents that had a death toll of more than 10 - equating to about one such accident every 7.4 days (Xiaohui & Xeuli, 2004). Even if accidents can be prevented there is still the risk of exposure to particulates. It is estimated that 45g of dust emissions are expelled for every ton of stone that is processed (Demkin, 1998). Left untreated this can cause pneumoconiosis, a disease of the lungs caused by long-continued inhalation of dust.

Coatings and adhesives

Adhesives are required for the manufacture of different wood-based boards. Out of the different types of boards, a low-density fibreboards requires the least adhesive – typically in the region of 1% by weight, but this can go up to 10% for high density fibreboards. Chipboard typically requires around 10% of adhesives, and orientated strand board requires 3-6% (Berge, 2009, p. 339).

Formaldehyde

It is difficult to manufacture some timber-based products without using a limited amount of formaldehyde (it occurs naturally at very low concentrations in any case). Formaldehyde is a carcinogen but at the concentrations involved in most products, the most serious consequence is likely to be some sort of allergic reaction (which is still highly unlikely) or an objectionable odour. In general the health implications have not been fully determined but are considered minimal. Formaldehyde is one of the more common indoor air pollutants. Its release is effectively 'blocked' and prevented from escaping by the veneer coverings that go on the surface and tolerable concentrations are managed by law. Low VOC/formaldehyde free products are more readily available in the USA (where the emphasis on Green Building is more Healthy Building rather than an ecological 'green' building approach). There is some availability of low VOC/formaldehyde boards in the UK although they appear to be weaker and less durable. VOCs can be avoided if solid panels are used. The greatest health risks appear to be if boards are cut up with a saw as this releases locked up formaldehyde and dust particles.

Formaldehyde alternatives

Melamine

Melamine is used to substitute for formaldehyde. From a toxicity point of view, it appears to be safe. Melamine coated boards are made by saturating pieces of paper with melamine resin which are then laminated onto the particleboard. The veneer is usually thinner than 3mm. An analysis of melamine resin suggests that its impact should be quite small (circa 0.2 kg CO₂ / m² for carcasses). The University of Bath indicates that veneered carcasses have about twice the impact of unveneered MDF or particleboard (ICE, 2008).