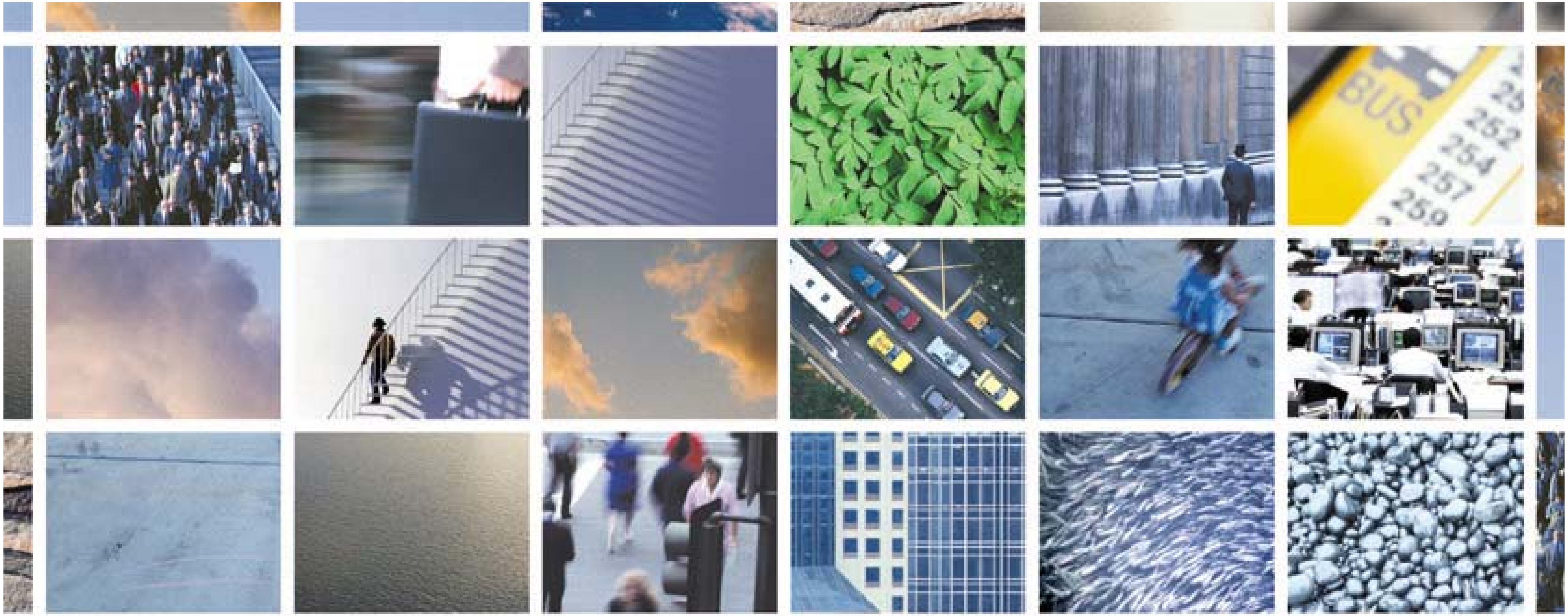

Study and Assessment of Available Information for a Pilot Project on a Teak Garden Chair

Final Report

November 2005

European Commission – DG Environment

Study and Assessment of Available Information for a Pilot Project on a Teak Garden Chair

November 2005

Reference: 7010401/2004/385651/MAR/G4

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(Please note that this study has been undertaken for the European Commission but that it does not necessarily represent the views of the Commission on any of the subjects covered in this report)

For and on behalf of:
Environmental Resources Management

Approved by:

Signed:

Position: Partner

Date:

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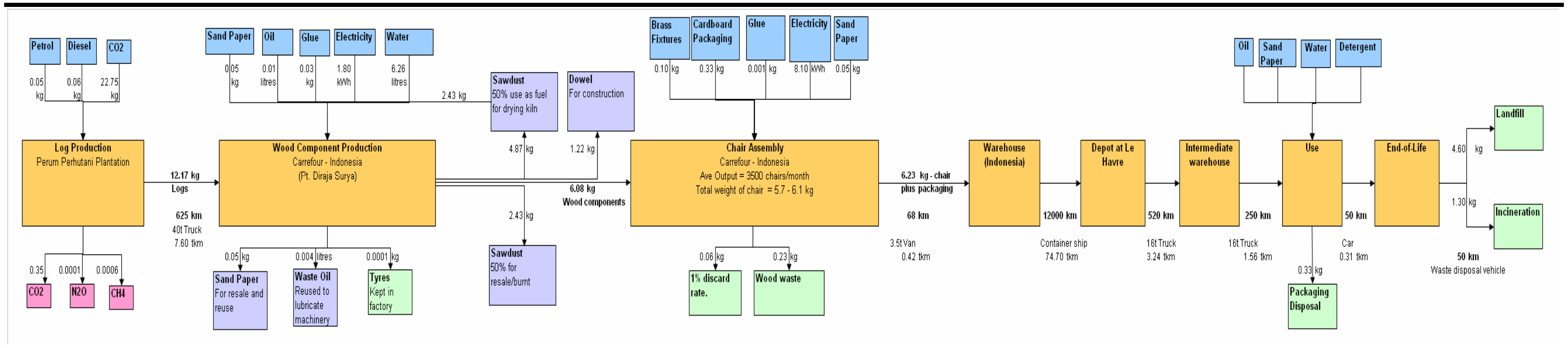
EXECUTIVE SUMMARY

In the context of its Integrated Product Policy (IPP), which aims at minimising the environmental impacts of products across their life cycle, in 2004 the European Commission launched two pilot projects to demonstrate how the IPP approach could work in practice. One of these pilot projects (on a teak garden chair) was proposed by Carrefour and ERM was asked to provide the background analysis for this project.

Task 1 of the project consisted of collecting relevant information related to the environmental impacts of the teak garden chair on the basis of stakeholder interviews and literature research (see Annexes A and B for further details), and resulted in a description of the product's life cycle:



In task 2 the collected information was compiled into a number of inventories, detailing the inputs to, and outputs from, each activity in the life cycle of the teak chair. These were subsequently assessed during task 3 in order to determine the potential environmental and human health impacts associated with individual activities, and across the chair's life cycle. Based on the results, an attempt was made to interpret the impacts across the life cycle of the teak garden chair, resulting in the following 'hot spot' identification:

	Impacts Assessed Using Quantitative Impact data						Impacts Assessed Using a Qualitative Scoring Method				
	Resource Depletion Cumulative Energy Demand (Non-Ren.)	Resource Depletion Cumulative Energy Demand (Renewable)	Water Resource Use	Global Warming	Acidification & Eutrophication	Eco-toxicity	Human Health	Land Transformation	Social Issues	Bio-diversity	Erosion
Teak (log) production	-	***	-	-	-	-	***	***	***	***	***
Brass Fastening production	-	-	-	-	-	***	-	-	-	-	-
Glue production	-	-	-	-	-	-	-	-	-	-	-
Oil/lubricant production	-	-	-	-	-	-	-	-	-	-	-
Sand Paper Production	-	-	-	-	-	-	-	-	-	-	-
Packaging material production	-	-	-	-	-	-	-	-	-	-	-
Teak Component Manufacture	-	-	-	-	-	-	**	-	-	-	-
Chair Assembly	-	-	-	-	-	-	-	-	-	-	-
Distribution	***	-	-	***	***	-	***	***	-	**	**
Use	-	-	***	-	-	-	-	-	-	-	-
End of life	-	-	-	-	-	-	**	**	-	*	*

Bearing in mind the data used for the analysis, assumptions made during the research and the concerns expressed by stakeholders, the following conclusions were drawn with respect to the areas for improvement related to the environmental performance of the teak garden chair:

- Teak production is a key concern for many stakeholders and scores high in all non-quantifiable impact categories;
- Given the low mechanisation of the chair production and assembly process, the key issue during this life cycle stage seems to be related to worker health and safety conditions;
- Distribution of the chair contributes significantly to non-renewable resource depletion and global warming as well as to several non-quantifiable impact categories;
- The use phase has a low overall contribution to all impact categories except for the use of water resources during maintenance of the chair (however, maintenance is significant in terms of reducing the overall impact of teak chair products);
- The end-of-life phase has impacts across the non-quantifiable impact categories;
- Extending the lifetime of teak chairs through good care and quality of manufacture has the greatest influence over the impacts that will arise through the use of teak chairs by consumers.

In task 4 a large number of possible instruments for addressing the environmental impacts were identified and described, leading to several recommendations for various actors in the supply chain. Based on the identification of the key environmental impacts under task 3 and the identified instruments for mitigating these impacts, the following key conclusions were drawn:

- The use of certified forest management systems is most likely the best tool for reducing the environmental impacts associated with teak log production. This should be assisted by the EU's FLEGT programme and other international initiatives in this area, such as the CGI process and campaigning activities by NGOs.
- The application of eco-design tools and strategies is an excellent way to address a number of other product impacts including waste minimisation and process optimisation during chair manufacturing, product and packaging weight and volume optimisation for more efficient distribution, and increased product quality and repairability to extend the product lifetime.
- A promising instrument to mitigate the impacts related to the use phase, end-of-life and lifetime of the teak garden chair is the use of consumer information. More extensive use of clear and easily understandable information should encourage consumers to maintain and repair their products properly and thus extend their lifetime. It will also allow for the provision of information about the best end-of-life options for the teak garden chair.

By encouraging a variety of stakeholders to play specific roles in a concerted effort to improve the overall environmental performance of the teak garden chair, the market as a whole could both be pushed (e.g. via the EU FLEGT process and NGO pressure) as well as pulled (e.g. via more and better information for consumers) into the desired direction. The simultaneous application of several instruments would facilitate such a development, bearing in mind that some of these could be implemented relatively quickly while others need more time to give the desired results. In this way, the IPP approach would provide real added value to environmental policy development in specific product sectors.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

All products cause environmental degradation in some way, whether from their manufacturing, use or disposal. In order to try to minimise this environmental impact, the European Commission has developed a new, product-oriented environmental policy strategy, called 'Integrated Product Policy' (IPP). The IPP approach involves looking at all phases of a product's life cycle and taking action where it is most effective[1].

As part of the IPP strategy, the Commission has initiated two innovative pilot projects – one on mobile phones and one on a teak garden chair - to show how IPP can work in practice. Environmental Resources Management (ERM) was selected to provide the background analysis to the second of those projects (the teak garden chair), which was proposed by Carrefour.

This background research consists of the collection, summary and assessment of information related to the environmental impact of a teak chair, based on literature research and stakeholder consultation. It will cover all stages of the product's life cycle, from the production and harvesting of teak, through processing, manufacturing of fixtures and fittings, chair assembly, packaging, distribution, retail, use and eventual disposal. On the basis of this assessment, options for the mitigation of the identified key impacts will be elaborated.

1.2 LAYOUT OF THIS REPORT

The remainder of this progress report sets out the results of;

- Task 1: Collection of relevant information (*Chapter 2*);
- Task 2: Summary of relevant information *(Chapter 3)*;
- Task 3: Assessment of relevant information (*Chapter 4*); and
- Task 4: Suggest ways to mediate these environmental impacts *(Chapter 5*).

Various annexes provide further background information to the research.

[1] More information about the Commission's IPP approach can be found on: europa.eu.int/comm/environment/ipp/home.htm

2 *TASK 1: COLLECTION OF RELEVANT INFORMATION*

2.1 *DATA COLLECTION*

Data collection involved a systematic process of identifying and quantifying the environmental impacts associated with the flows through each life cycle stage. This was carried out through two main routes:

- Literature review; and
- Stakeholder consultation.

2.1.1 *Literature Review*

An extensive literature search was carried out in order to collate all sources of data and information relating to activities across the life cycle of the teak chair. The search was, in particular, focused on activities associated with teak production and processing, as this is an area for which little quantified data exists. In comparison, reliable and peer-reviewed Life Cycle Inventory (LCI) datasets exist for the majority of other activities in the teak chair life cycle, such as brass component production, packaging production, auxiliary material production, transportation and waste treatment.

A reference library of all relevant and significant information sources was generated as a result of this task and can be found in *Annex A*.

2.1.2 *Stakeholder Consultation*

In conjunction with the literature review, a stakeholder consultation process was undertaken. The consultation included the interviewing of stakeholders across Europe and in Indonesia, covering different stages of the life cycle. Information was gathered through these discussions and from the provision of supporting references by those that were interviewed.

A data extraction package was developed that outlined the project, background to the project and in particular the aims of the consultation. This included key questions that were developed and used as a prompt. Consultations took place with over 20 different organisations, through a combination of email and telephone communications (the background document, key questions and details of stakeholders consulted can be found in *Annex B*).

Other than Carrefour, no other stakeholder provided significant, quantitative data regarding the environmental impact of the teak garden chair. Most information provided was of a generic, qualitative nature and largely relating to sustainable forestry and plantation forestry issues, including illegal logging, social impacts, and biodiversity.

2.2 *BACKGROUND TO TEAK PRODUCTION IN INDONESIA*

2.2.1 *Teak Plantations*

Teak (Tectona grandis) is said to be indigenous to India, Burma, Thailand, Indochina and Java, Indonesia and is a deciduous tree, which grows particularly well in the dry, hilly terrain. It has been extensively planted for timber or as an ornamental within its natural range and throughout the tropical regions of the world, including East and West Africa, as well as Cuba and the Caribbean, and South America from Panama to Brazil.

Java has very large teak plantations, which were first planted by the Dutch in the early 1800's. Teak production rotation is on average 60-80 years however there is a trend in Java towards younger plantations, which might have longer-term social, environmental and economic implications. Rotations of 40 years are not uncommon. Production rates can be in the region of 100-120 m^3 per hectare, although where poor management has depleted stocks of standing timber, yields can be much lower. Teak production in Java is of significant economic and social value. The teak plantations produce a high value crop that is an important source of income to local communities and to the local industry as a whole. The associated furniture and timber products industry provides regular local employment to many thousands of people in Java.

There are two main sources of teak in Java, the Jepara region and PT. Perhutani. The Jepara region comprises of many small-scale, often family run, producers making teak furniture by hand, at often low cost and of varied quality. There is scope for the intermixing of supply from numerous and often unknown sources. PT. Perhutani, a government parastatal agency, manages the main plantations in Java. Of these teak plantations, approximately half of the area of teak plantation is in productive use and the remainder is protected, to enable regeneration of the forest after heavy depletion from illegal and uncontrolled logging. PT. Perhutani is working with WWF and the Tropical Forest Trust (TFT) in 10 of its districts to improve the forest management practices, aiming for certification (FSC certification was revoked in 2001 for non-compliance).

2.2.2 *Illegal logging and sustainable forestry*

Illegal logging can be defined as the breaking of laws on cutting, processing and transporting timber or wood products. This can include logging in protected areas (such as national parks) or over the allowed quota, by processing the logs (for example into plywood or pulp and paper) without acquiring licences, and by exporting the timber and wood products without paying export duties. Illegal logging and the trade in illegally logged timber is a major problem for many timber-producing countries in the developing world. It causes environmental damage, costs governments billions of dollars in lost revenue, promotes corruption, and undermines the rule of law and good governance.

It is estimated that as much as 70% of all timber extracted, traded or exported in Indonesia is done so illegally, including CITES listed species (such as Ramin and Gaharu). This timber is very often exported to other countries for processing and then enters the 'legal' international market without mentioning the origin. Illegal logging is said to equal at least twice the amount of the annual allowable cut for the country. It is estimated that illegal logging loses the Indonesian government more than $1bn a year (out of a total budget in 2003 of about $40bn). To keep prices down in the international markets, illegally sourced timber is often intermixed with legally sourced timber at the mill and processing plant.

In 1990, PT. Perhutani obtained one of the first forest certificates in Indonesia, issued by the Rainforest Alliance's SmartWood programme. Following the establishment of FSC in 1993 and the development of Principle 10 relating to plantations in 1996, SmartWood – an FSC accredited auditor - reassessed PT. Perhutani's operation and gave out FSC certificates to five forest blocks in 1998 and 2000. However, PT. Perhutani lost this certification in 2001 due to non-compliance in some of its districts (see box 1 for a summary of key non-compliance issues in one of its districts).

While no teak plantations in Indonesia have FSC or equivalent certification, PT. Perhutani does however operate a policy and management plan regulating the harvesting rates, production processes and addressing environmental concerns (for example, the inclusion of buffer zones and protection of high conservation value forest). PT. Perhutani is now working with the Tropical Forest Trust (TFT) and WWF towards certification, improving its forest management practices, including social issues and working with processing factories further along the supply chain to ensure that products can be tracked back to stump by an independent (third party) verifier.

Box 2.1 *Summary of non-compliance issues resulting in the suspension of the FSC Certificate for the Madiun District*

In summary, the following main issues stand out from the audit that would support the suspension of the certificate:

1) By not meeting numerous conditions and Corrective Action Requests (CARs) , PP is not in compliance with Principle 1 "*commitment* to FSC P&C";
2) Unreported security issues (where people were seriously injured or killed);
3) Not reporting theft figures on a quarterly basis as per conditions and CARs and figures given SW at the audit are inconsistently calculated;
4) Exceedingly high levels of illegal logging of teak within PP plantations;
5) Allowable cut being seriously and increasingly undermined making it unreliable to certification;
6) Lack of serious commitment to community involvement in forest management;
7) Unknown consequences to certification due to the organizational changes from Perum to Persero, with significant uncertainty about how PP will operate vis-à-vis the social aspects of their management after becoming a state-owned private company.

The audit team therefore recommended that the certification of Forest Management District (KPH) Madiun be suspended until the satisfactory resolution of all applicable conditions and CARs. The timeframe for compliance with all CARs was changed to "Prior to re-instatement of the suspended certificate". KPH Madiun had 18 months from the day of their suspension, October 20, 2001, to comply with the applicable conditions and CARs in order to reinstate their certification. After that date, the KPH would have had to undergo a full assessment to re-establish their certification. Thus far the certification has not been re-established.

Source: Public Summary Document for Perum Perhutani, by Smartwood

2.2.3 *Furniture Production*

Although relatively unimportant in terms of the volume of world timber production, teak is the tropical hardwood most in demand for a specific market of 'luxury' applications including furniture, shipbuilding and decorative building components, because of its strength and aesthetic qualities. It is thus of major importance for the forestry economies of its main producing countries. The main furniture production area is Jepara, which consists of numerous small workshops where furniture is hand-made or semi-hand made. With so many small workshops it is practically impossible to know the origin of timber used in the furniture production, including its legal origin and the sustainability of the production methods used. With small factories, hand making the products, low mechanisation, unknown sources of timber, the end product (teak garden chair) can be more than 30% cheaper than the price of a chair made in a factory using mechanised practices. The quality of the product also differs, reflective of the raw material, the production process and the end price.

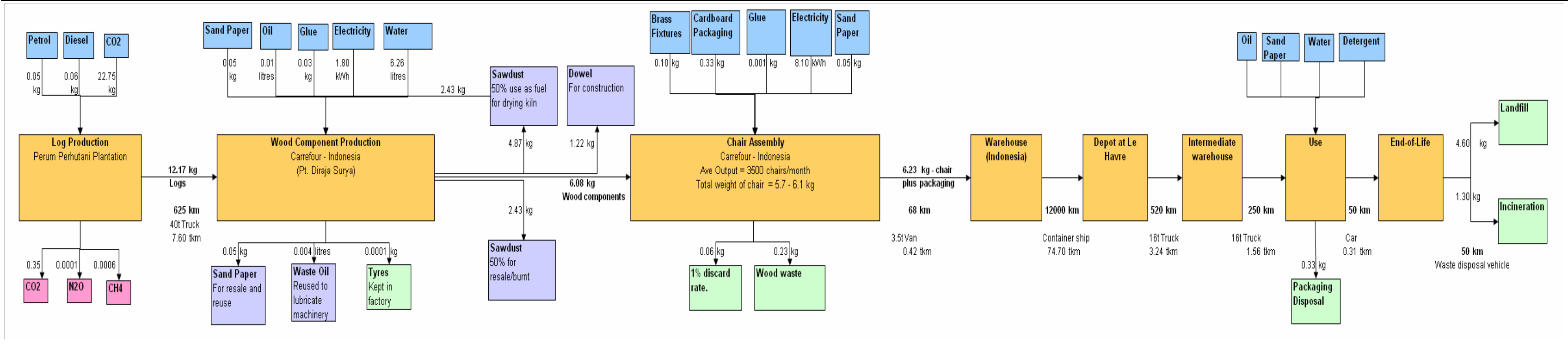
Alternatively, furniture can be machine-made in factories, which typically allows for better control over the origin of the timber and the quality of the product. With a higher product quality and more influence over the design of the product, the furniture is expected to have a longer life, albeit at a higher cost.

2.3 SCOPING

An initial scoping exercise was carried out in order obtain a detailed understanding of the product life cycle and determine the significant material and energy flows, transportation and emissions associated with each life cycle stage. This was based on consultations with Carrefour, other stakeholders and by reference to literature sources.

The flow diagram below (*Figure 2.2*) provides an overview of the key material and energy flows across the life cycle of the teak garden chair.

Figure 2.2 ***Teak Chair Life Cycle***



Sections *2.3.1* to *2.3.8* provide further detail on the key activities involved

2.3.1 *Teak Production*

All timber used for the teak garden chair produced by Carrefour is sourced from PT. Perhutani, and not from the Jepara region, to permit the tracking of timber and thus ensure (as far as is possible) that all timber used in the production of garden chairs is both legal and sustainable. PT. Perhutani itself is working with TFT and WWF (5 districts with each) to improve its existing

management practices, which are already well established and thorough in their application, with the long term goal to have FSC certification reinstated.

Following the loss of FSC certification, Carrefour worked directly with the factory producing the garden chairs, and with CIFOR and CIRAD, to establish a chain of custody process that would help all timber used in the production of the chairs to be tracked back to stump. The factory is currently working with WWF Indonesia and Global Forest Trade Network (GFTN) to improve its existing system, with WWF providing independent verification of the tracking system in place. This Wood Purchasing Process is described briefly below and illustrated in *Annex F*.

1. Obtaining a licence.
   The factory (Carrefour's supplier) obtains a stamped licence from PT. Perhutani for the future purchase of logs. Such a licence, detailing the origin and quota of available logs, is required so that the factory can proceed to choose logs.
2. Selection of the logs.
   The factory chooses the logs depending on size, grade and price. PT. Perhutani pricing is based on the quality (grade), length and diameter of each chosen log.
3. Initial payment of deposit and tax.
   Tax and a deposit have to be paid first by the factory.
4. Issuing of final invoice with official list of the chosen logs.
   Following the down payment, a final invoice (including a further 10%¨VAT) is provided by PT. Perhutani detailing the logs purchased.
5. Issuing of official licence for the sale of the logs.
   PT. Perhutani officials issue a licence for the sale of the chosen logs which details the origin and volume
6. Payment.
   PT. Perhutani then require payment before they issue the delivery order
7. Confirmation of receipt of payment.
   PT. Perhutani provide confirmation that they have received payment
8. Issuing of log delivery order.
   Following payment, the order is given by PT. Perhutani to deliver the logs. The order details the truck number, the number and volume (m3) of logs as well as the factory to which the logs will be delivered. The log delivery order is a key element in the chain of custody and is accompanied by a detailed list of each log that was purchased.
9. Log delivery to the factory.
   Upon delivery of the logs to the factory there are a number of control points which include checking:
   - The truck number;

- The quantity of logs;
- The log dimensions;
- The log reference numbers; and
- That all logs have the registered number from the government.

2.3.2 *Teak Component Production*

Teak components are manufactured in a factory in Indonesia and the production is largely machine-based. The logs are received and sawn into lengths. From these, rough components are cut and dried for approximately one month in air, and using a kiln. The kiln is fuelled using sawdust and chippings from the sawing processes undertaken at the factory. Following drying, components are machine-sanded and the necessary holes and grooves are cut. The final components are then passed on to the chair assembly process, which is undertaken in the same factory.

2.3.3 *Brass/Component Production*

Brass is an alloyed form of copper, of which zinc is the most important alloying element. As with other copper alloys, the brass is produced by melting together copper and zinc and casting ingots. The casting of brass to its final form then melting the alloy and pouring into a mould, commonly made or either steel or sand.

2.3.4 *Packaging Material Production*

Cardboard packaging production involves three basic steps: base paper production; corrugated board production; and forming boxes from the corrugated board.

The base paper is produced through a series of steps involving de-inking (in the case of recycled paper as the source of fibres), pulp production and machining of the paper. The paper is then conditioned with heat and steam and fed between large corrugating rolls, giving it its fluted shape. Starch is applied on one side of the flutes and the inner liner is glued to the fluting. This corrugated fluting medium with one liner attached is called a single face web. One or more single face webs and an outer liner are glued together to form corrugated board. Finally, the corrugated board is heated, by steam, to a temperature at which the glue (starch) will bond. In the third step, corrugated board is cut, printed and folded in order to produce a cardboard packaging box.

2.3.5 *Chair Assembly*

Teak components are received into the factory and the fixed parts (e.g. back leg with its slats, seat with its slats) are assembled with polyurethane glue in the assembling area. Processing is carried out using pneumatic machinery. When all the wooden parts are assembled (seat part, back rest, and front leg), the chairs are moved to a further assembly area. At this point, the brass hardware is fitted and the chairs' functioning is tested. Before packaging, the chairs are then sanded again, with a higher level of sand paper. In the final step, the chairs are packaged and stored in a warehouse.

2.3.6 *Distribution*

Following manufacture, there are a number of steps in the chair's distribution chain. Chairs leave the assembly factory and are transported 68km by truck, in loads of 150 chairs, to a warehouse in Surabaya. From there they are taken by 40' container ship, in loads of 812 chairs, to Le Havre. From Le Havre, the chairs are then distributed firstly to five intermediate warehouses throughout France and then to more than 200 retail outlets across the country.

2.3.7 *Chair Use*

Two, alternative scenarios for maintenance are provided in the instructions to consumers. The first involves leaving the chair to age naturally: *"use sand paper to remove stains as necessary. If mould develops wash with a light detergent, leave to dry and sandpaper"*. The second involves protecting the chair with oil: *"wash chair, sand paper, leave to dry and apply a fine coat of teak oil 1-2 times per year. Repeat the sanding and washing process every 3 years"*.

There is no requirement for further treatment and so the wood will remain in a relatively natural state. However, there is potential for contamination if the chair is not used according to provided instructions, for example if paint or varnish is applied. Alternative treatment methods such as these have not been addressed during the assessment of the teak chair, with the exception of their potential influence on the chair's treatment at end of life.

2.3.8 *End of Life*

There are a number of alternative waste treatment routes that the chair could take at the end of its life: landfill; incineration; or recycling. The predominant routes are currently considered to be landfill and incineration, as it has been advised that post-consumer chairs are unlikely to be recycled to due to the potential for the waste wood to be treated as contaminated.

3 *TASK 2: SUMMARY OF RELEVANT INFORMATION*

The information collected during *Task 1* was compiled into a number of inventories, detailing the inputs to, and outputs from, each activity in the life cycle of the teak chair. These were then assessed in order to determine the potential environmental and human health impacts associated with individual activities, and across the chair's life cycle.

The aim of the project was to extract data describing and quantifying the impacts associated with each stage in the life cycle of the chair. As indicated in *section 2.1*, the research resulted in only a limited amount of data directly relevant to the teak garden chair life cycle. Impacts were identified but limited or no data describing the scale of the environmental or health impacts associated with the teak garden chair were available. In this situation the proposed method was to estimate the scale of potential environmental impacts, normally assessed through LCA, by conducting a quick life cycle screening assessment. This assessment involved the use of generic LCI data for material and energy flows similar in nature to those associated with the teak chair. There was no scope to collect LCI data specific to the teak chair (e.g. by going to Indonesia and measure the manufacturing emissions). The quick assessment conducted reflects the level of assessment available to those organisations who have limited time and resources but who wish to gain an appreciation of the scale of the environmental impacts that are associated with their activities and products on a life cycle basis. For those impacts, such as biodiversity, human health, land transformation soil erosion and social issues, identified by stakeholders, which are not normally assessed through LCA and for which no data was obtained it was necessary to assess scale of impact through a qualitative approach. The overall objective was to provide an estimate of scale of environmental impact that would arise through the life cycle of a chair.

3.1 *IMPACT ASSESSMENT METHODOLOGY*

All the potential effects resulting from activities in the life cycle of the teak chair were grouped into a number of impact categories (resource depletion, global warming potential, land change, biodiversity, erosion etc.) These impact categories were then divided into two groups, according to whether an activity's contribution to the impact could be quantified, or if only a qualitative assessment of the magnitude of the impact could be made.

3.1.1 *Quantitative Indicators*

Established life cycle impact assessment (LCIA) methods (cumulative energy demand and Eco-Indicator 99), detailed in the ECOINVENT database, were used to calculate environmental effect scores for each activity and category of impact. The database consists of more than 2700 unified and generic LCI datasets for the reference year 2000. It includes characterisation methods for calculation of impact values. Impact profiles for the inputs and output material and energy flows for the teak chair life cycle (see *Section 2.3*) were extracted and multiplied by the flow amounts. This resulted in an estimate of scale of impact for each life cycle stage. A description of the methods used during this assessment can be found in *Annex D*.

Details of all assumptions or substitutions that were made during the quantitative assessment and listings of all data sources can be found in *Annex E*.

3.1.2 *Qualitative Indicators*

Where quantitative analysis was not feasible due to the nature of the impact and/or lack of appropriate information, a qualitative assessment was undertaken. A scoring system was developed to permit a uniform approach to scoring the following impacts: soil erosion, land transformation, human health, biodiversity and social issues.

The scoring system has four key components against which a series of statements or measures are presented that represent high, medium or low risk. The key components are: Level of concern with this type of industrial process for this issue; level of management by process owner, scale of particular operation and the weight of the material flow attributable to this product. This approach reflects the philosophy of the quantitative approach in that the impact contribution that arises from a specific industry sector is allocated to this specific teak chair.

The scores attributed to the Carrefour chair reflect the Carrefour chair performance. If the methodology was applied to another chair higher or lower scores may be achieved. This allows for comparison and improvement to be monitored, and reflects the philosophy of the quantitative approach in *section 3.1.1*.

Though the methodology is fit for purpose it is undoubtedly true that, with further research, a more robust method could be developed.

To support the scores a brief description of the methodology is provided in *Annex C.*

3.1.3 *Environmental Impact Results*

Quantitative and qualitative impact values for the whole life cycle of the teak chair are presented in *Annex E*. *Table 3.1* provides the same information but expressed as the relative contribution of each life cycle stage to the total impact in each impact category.

Table 3.1 Percentage Contribution of Each life Cycle Stage to Impact Categories

	Impacts Assessed Using Quantitative Impact data						Impacts Assessed Using a Qualitative Scoring Method				
	Resource Depletion (non-renewable)	Resource Depletion (renewable)	Water Resource Use	Global Warming	Acidification & Eutrophication	Ecotoxicity	Human Health	Land Transformation	Social Issues	Biodiversity	Erosion
Teak (log) production	16%	91%	2%	15%	16%	4%	27%	32%	59%	42%	42%
Brass Fastening production	4%	0%	8%	2%	6%	66%	0%	0%	0%	0%	0%
Glue production	3%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%
Oil/lubricant production	2%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Sand Paper Production	2%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Packaging material production	5%	1%	5%	3%	2%	1%	1%	2%	1%	1%	1%
Teak Component Manufacture	6%	1%	13%	6%	2%	1%	18%	3%	2%	2%	2%
Chair Assembly	6%	1%	4%	4%	2%	1%	5%	3%	2%	2%	2%
Distribution	51%	1%	7%	57%	62%	23%	27%	33%	20%	29%	29%
Use	5%	4%	59%	11%	7%	2%	2%	3%	2%	2%	2%
End of life	0%	0%	0%	0%	2%	1%	19%	24%	14%	20%	20%

Based on the summary of results presented in the previous chapter, an attempt was made to interpret the impacts across the life cycle of the teak garden chair.

4.1 INTERPRETATION OF IMPACTS

4.1.1 *Hotspot identification*

For each impact category, the impact values were converted to highlight those impacts that have a contribution greater than 50% of the largest contribution to that impact category. *Table 4.1* shows those contributions, identified by red asterisks.

Table 4.1 Hotspot Identification for the Carrefour Teak Chair

	Impacts Assessed Using Quantitative Impact data						Impacts Assessed Using a Qualitative Scoring Method				
	Resource Depletion Cumulative Energy Demand (Non-Ren.)	Resource Depletion Cumulative Energy Demand (Renewable)	Water Resource Use	Global Warming	Acidification & Eutrophication	Eco-toxicity	Human Health	Land Transformation	Social Issues	Bio-diversity	Erosion
Teak (log) production	-	***	-	-	-	-	***	***	***	***	***
Brass Fastening production	-	-	-	-	-	***	-	-	-	-	-
Glue production	-	-	-	-	-	-	-	-	-	-	-
Oil/lubricant production	-	-	-	-	-	-	-	-	-	-	-
Sand Paper Production	-	-	-	-	-	-	-	-	-	-	-
Packaging material production	-	-	-	-	-	-	-	-	-	-	-
Teak Component Manufacture	-	-	-	-	-	-	**	-	-	-	-
Chair Assembly	-	-	-	-	-	-	-	-	-	-	-
Distribution	***	-	-	***	***	-	***	***	-	**	**
Use	-	-	***	-	-	-	-	-	-	-	-
End of life	-	-	-	-	-	-	**	**	-	*	*

This hotspot identification highlights the following key issues:

- Depletion of renewable resources, human health, land transformation, social issues, biodiversity and erosion during teak (log) production;
- Ecotoxicity for brass fastening production;
- Human health for teak component manufacture;
- Depletion of non-renewable energy resources, global warming, acidification & eutrophication, human health, land transformation, biodiversity and erosion for distribution;
- Water resource use during use; and
- Human health, land transformation, biodiversity and erosion during end of life.

4.2 SIGNIFICANCE OF IMPACTS

The scale of the impacts assessed quantitatively for a single Carrefour teak chair are considered to be relatively small. For example, the global warming burden is between 10 kg and 15 kg CO2 equivalents, fossil energy consumption is in the order of 40 kWh and water consumption for the whole life of the chair is approximately 100 litres. Over 20 years (the anticipated life of the Carrefour teak chair) these numbers appear to be small in the context of many other consumer products. Nevertheless, the combined impacts of all teak chairs would represent large quantities in themselves.

Though the teak chair contributes across the range of impacts, the data and the concerns of stakeholders suggest that the impact categories determined quantitatively are not as significant as those assessed qualitatively. In terms of the impacts typically associated with fossil resource and fuel consumption, teak chair production and use are considered, and are shown, to be of low intensity. The main environmental issues are those associated with land use and social interactions through extracting and processing teak timber.

The significance of the teak log production phase is underlined by the continued focus of NGOs, Member State governments and the European Commission on sustainable forest management and illegal logging. The environmental and social impacts during this life cycle phase are considered by many to be of key importance and deserving of continued attention.

Carrefour states that the lifetime of chairs manufactured by hand, typically in poorly controlled, small-scale factories, could be a factor 3 lower than their chair. Not only are the whole life impacts likely to be higher for these poorer quality chairs, but also the impacts per year will be significantly higher. In the context of the teak chair, the lifetime of the product is considered to be the single most important factor in reducing the impact of the use phase on the environment.

4.3 SENSITIVITY ANALYSIS

The sensitivity of key variables and assumptions identified during the impact assessment was tested by altering the parameter and investigating its affect on the results. It was found that a number of assumptions had a significant affect on results, and should be taken into account when developing policy options:

- The assumed electricity consumption during chair assembly had a dominant affect on the relative impact of the assembly process in the majority of impact categories;
- Assumed transport distances unsurprisingly had a significant affect on results for most impact categories;
- Waste disposal assumptions (see *Annex E*) had a significant affect on results, such that the overall energy demand of the chair over its life cycle decreased by almost 30 MJ (15%), although the global warming potential of this life cycle stage increased by almost three-fold;
- The impact categories that were assessed qualitatively are the most sensitive element of the assessment. A change in any one of the three qualitative scoring assessment criteria (level of concern, management, issue) can significantly affect the results (see *Annex C*);

To test the sensitivity of the data used for modelling electricity impacts, the electricity mix used was substituted with a European (UCTE) electricity mix and electricity mixes for other European countries (for example, Portugal). It was found that the percentage contribution of the teak component production and chair assembly life cycle stages were slightly increased (less than 5 percentage points) in some categories. However, the hotspots identified within the teak chair life cycle were not affected. The hotspots identified in *Table 4.1* remain the same, regardless of electricity mix modelled.

4.4 CONCLUSIONS

Bearing in mind the data used for our analysis, assumptions made during the research and the concerns expressed by stakeholders, the following conclusions can be drawn with respect to the areas for improvement related to the environmental performance of the teak garden chair:

- Teak production is a key concern for many stakeholders and scores high in all non-quantifiable impact categories;
- Given the low mechanisation of the chair production and assembly process, the key issue during this life cycle stage seems to be related to worker health and safety conditions;
- Distribution of the chair contributes significantly to non-renewable resource depletion and global warming as well as to several non-quantifiable impact categories;

- The use phase has a low overall contribution to all impact categories except for the use of water resources during maintenance of the chair (however, maintenance is significant in terms of reducing the overall impact of teak chair products);
- The end-of-life phase has impacts across the non-quantifiable impact categories;
- Ecotoxicity for brass fastening production will most likely not be a significant impact bearing in mind that brass fastenings are only a small component of the total chair (i.e. 100 grams vs. 6 kilograms);
- Depletion of renewable resources is somewhat unavoidable for a chair made of wood.
- Extending the lifetime of teak chairs through good care and quality of manufacture has the greatest influence over the impacts that will arise through the use of teak chairs by consumers.

As indicated above, teak production is considered to be by far the most important part of the product life cycle and the other life cycle stages of the teak garden chair are of less significance in terms of their overall contribution to the environmental impacts. However, as the purpose of this project phase is to identify the areas of improvement for the teak garden chair itself, ERM proposes to focus task 4 on the following impacts, with emphasis on the first one:

- Sustainability issues during teak (log) production – which includes sustainable management practices, illegal logging, social and economic considerations;
- Worker health and safety during chair manufacturing;
- Non-renewable energy use during distribution;
- Water use during the use phase;
- Landfill and incineration during end-of-life; and
- Lifetime extension.

Finally, ERM would like to stress that the lack of quantitative data directly applicable to the teak garden chair means that the assessment of impacts will be subject to a potentially high level of uncertainty, as, unavoidably, the analysis has had to rely on qualitative assessments. This introduces a certain level of subjectivity and the final results should be interpreted in this context.

ERM has not undertaken an LCA of the teak garden chair but has provided an expert interpretation of available data. We believe this should be sufficient to comply with the aims of this project even though the assessment has been limited by the lack of data specific to the environment impacts associated with the production of the teak chair.

5 TASK 4: SUGGEST WAYS TO MEDIATE THE ENVIRONMENTAL IMPACTS

5.1 AN OVERVIEW OF POSSIBLE INSTRUMENTS

The Communication on Integrated Product Policy presented a wide range of possible tools to improve the environmental impact of products and services, ranging from environmental management systems and eco-design to eco-labelling and the greening of public procurement.

Based on the significant environmental impacts identified in task 3, ERM has developed an overview of possible instruments for addressing these impacts. This overview is not meant to be exhaustive but aims at identifying the most important tools that can be used for mitigating the identified key impacts. These instruments could be implemented either at EU level, by individual Member States, by Carrefour or by other companies involved in the product chain for teak garden furniture.

Table 5.1 ***Overview of possible instruments to mitigate the identified environmental impacts***

	Significant environmental impacts												
	Teak log production					**Chair manufacturing**	**Distribution**	**Use**	**End of life**				**Life-time**
Possible instruments	Human Health	Land Transf	Social Issues	Bio-diversity	Land erosion	Worker Health and Safety	Non-renewable energy use	Water use	Human Health	Land Transf	Bio-diversity	Land erosion	All
(Certified) Forest Management Systems	√*	√	√	√	√								
(Certified) Environmental , Health and Safety Management Systems						√							
Voluntary agreements (e.g. Charters, pacts, conventions, etc.)	√	√	√	√	√	√							
Eco-design						√	√						√

Possible instruments	Significant environmental impacts												
	Teak log production					Chair manufacturing	Distribution	Use	End of life				Life-time
	Human Health	Land Transf	Social Issues	Bio-diversity	Land erosion	Worker Health and Safety	Non-renewable energy use	Water use	Human Health	Land Transf	Bio-diversity	Land erosion	All
Logistics planning							√						
Packaging standards							√		√	√	√	√	
Consumer information	√	√	√	√	√	√		√	√	√	√	√	√
Waste legislation									√	√	√	√	
Product guarantees													√
Availability of spare parts													√
Eco taxes	√	√	√	√	√	√	√	√	√	√	√	√	√
Eco-labels	√	√	√	√	√	√	√	√	√	√	√	√	√
Green public procurement	√	√	√	√	√	√	√	√	√	√	√	√	√
Green corporate procurement	√	√	√	√	√	√	√	√	√	√	√	√	√
Corporate reporting	√	√	√	√	√	√	√	√	√	√	√	√	√

* Please note that some instruments will also have an effect on other parts of the product life cycle. However, we have highlighted those areas where this effect is deemed greatest.

5.2 *DESCRIPTION AND ASSESSMENT OF POSSIBLE INSTRUMENTS*

Choosing the right policy tool, or mix of tools, depends on a range of considerations, including the significance of the environmental impact, where that impact takes place, the key actors involved, the preferred policy intervention, possible socio-economic impacts, etc. Within the IPP pilot project exercises, choosing the right mix of tools to improve the environmental impact of the product is the task of the stakeholder group. To facilitate this task, ERM has analysed the suitability of the

identified instruments by looking at the framework conditions, potential benefits and socio-economic considerations, and by making recommendations. The remit of the study only allowed for a qualitative assessment of the various tools.

Table 5.2 ***Assessment of possible instruments to address the significant environmental impacts during teak log production***

Identified impact	**Human health, land transformation, social issues, biodiversity and land erosion during teak log production**			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
(Certified) Forest Management Systems	Forest management systems are aimed at establishing a set of procedures that allow for a systematic approach to the management of forests, from pre- to post- harvest, including for example inventory, planning, extraction, road construction and transportation to mill. Such systems are typically based on national forest codes and regulations, as is the case in Indonesia, and are often modelled on international criteria and indicators, such as those of the ITTO and FAO. Good forest management can be verified by an independent third party, who could be accredited by a certifying body. Resulting products are sometimes labelled accordingly. There are a number of forest certification schemes such as FSC, PEFC, MTCC, etc. FSC, for example, operates a system of forest certification and product labelling that allows consumers to identify wood	The implementation of a good forest management system requires at a minimum the long term commitment of the concession manager and the allocation of sufficient resources over time. Good forest management – better planning, inventory management, proactive marketing and sales, typically result in lower costs and less environmental damage in the medium term. Good wood means good business – to adopt a sustainable forest management plan, with certification of the forest management and chain of custody to end buyer, will have significant benefits in terms of corporate social responsibility, reducing reputational risk, engaging positively with NGOs, maintaining market share and attaining price premiums.	Good forest management incorporates socio-economic concerns. To be able to manage the concession in a sustainable way, the needs and resource uses of the local communities must be taken into account and included in the overall management plan, with the aim to minimise the potential negative impacts on the local communities. Certification includes an assessment of the impact on socio-economic factors. Forestry concessions are also an important source of local employment and contribute to population welfare. There are initial investment costs involved, for example for conducting a thorough inventory and forest management planning exercise. These costs can however be recuperated through lower extraction and management costs in the longer term. Costs of auditing and verification are additional to those required for the implementation of good forest management and for some products a price premium is	PT. Perhutani is working with TFT and WWF (total of 10 districts) to improve its existing management practices, which are already well established. The long-term goal is to have FSC certification reinstated. Carrefour worked with CIRAD and CIFOR to develop chain of custody systems as a precursor to and key component of FSC certification. For buyers the certification of the chain of custody is just as important as the certification of the forest operation itself, for example to avoid mixing certified with non-certified products at the mill. Carrefour has an extensive tracking system in place. By working with WWF Carrefour is building a relationship with its supplier, working together to ensure legal and sustainable products are produced and sold. By linking producers directly with buyers, there is a more secure and long term benefit for the

Identified impact / Possible instrument	Human health, land transformation, social issues, biodiversity and land erosion during teak log production			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	and wood-based products from well-managed forests.		currently in existence. Next to this, taxes and royalties have to be paid to government, contributing to the local and national economies.	producer to adopt sustainable practices and ultimately certification. Therefore, we recommend that Carrefour continues to work on its chain of custody tracking system, and supports the work of PT Perhutani with WWF and TFT. Next to this, Carrefour could look for other, certified sources of teak, provided these are available in sufficient volume. Moreover, other companies (e.g. other retailers or distributors) could be persuaded by governments or by their peers to implement similar systems, for example via the use of voluntary agreements.
Voluntary Agreements (e.g., Charters, pacts, conventions, etc)	Many international public organisations (e.g. UN, WHO, ILO) and trade associations have established codes of conduct and best practice rules that aim to address social, economic and environmental issues of forest management, specifically in developing	For these voluntary agreements to be effective, they have to address the relevant aspects of good forest management. Companies on both sides – buyers and producers – have to be committed to the agreement and require the development of stronger trading and working	Most voluntary agreements in this area do address social concerns and adherence to them is bound to improve the social conditions implicated in log production. For example, the TTF RPP is based on a similar standard as the UK Government Procurement policy on this issue, and thus covers environmental, economic and	Carrefour, through their work with CIRAD and CIFOR, and via TFT and WWF working with PT Perhutani, continues to develop a close working relationship with its supplier. The strong relationship that already exists between Carrefour, the mill and PT Perhutani provides a solid

[1] As part of the EU's drive on illegal logging, the EU FLEGT Action Plan has as a core element the implementation of Voluntary Partnership Agreements (VPA) and Indonesia has been identified as a pioneer country to have one of the first Agreements in place. The VPA will be an agreement between the EU and Indonesia, with an action plan and supporting technical and financial assistance. A key

Identified impact Possible instrument	Human health, land transformation, social issues, biodiversity and land erosion during teak log production Description	 Conditions and benefits	 Socio-economic considerations	 Recommendations
	countries[1]. Some key developments include: The UK and Dutch timber trade federations have developed Responsible Purchasing Policies (RPP). All their members have to commit to buying from sustainable and legal sources. In particular, both federations are working with a number of mills in Indonesia. The French and the EU wide timber trade federations have adopted similar procurement policies to the UK and the Dutch policies. In turn, individual buying organisations are at varying stages in the development of purchasing policies. Buyers, through the RPP, are building closer relationships with their suppliers, requesting them to complete a questionnaire to	relationships. Moreover, companies signing up to such agreements need to adhere to the various requirements. To facilitate this, some sort of monitoring mechanism could be established. For example, companies in the UK Timber Trade Federation (TTF) RPP are required to monitor and report on an annual basis on the status of their suppliers. The benefits of using such voluntary agreements are that, typically, companies sign up to basic principles and rules, after which the implementation can be done on an individual basis. This could result in a cost-effective approach but care has to be taken that actual results are achieved. Individual companies stand to benefit from the legality	where possible social concerns. Of course, signing up to voluntary agreements will bring with it the additional costs of implementing and complying with agreement's requirements, both for producers (i.e. suppliers of wood and wood products) and buyers. However, by building relationships with buyers, suppliers maintain market access and, in the short term, there are price premiums for certain products for which legality as a condition of contract and evidence of sustainability during production can be shown. It is widely recognised that global timber prices are deflated due to the undercutting in the market by illegal products (An AF&PA study in 2004 showed global wood product prices deflated by 7 to 16% depending on the product). Therefore, there is an	basis for the development of a voluntary scheme. Through Carrefour's CSR and reporting targets, a questionnaire approach such as the one used by the UK TTF RPP, could be applied and monitored, against a set of targets. Impetus is to maintain market access. Carrefour is aware that it can obtain cheaper teak from alternative sources but accepts that to ensure legality and sustainability a higher price for the raw material has to be paid. Therefore we recommend that Carrefour continue to work closely with its suppliers and potentially adopts the questionnaire approach currently being rolled out in the UK by the UK TTF. Again, other companies (e.g. other retailers or distributors) could be persuaded to

component will be legality licences. All exports from Indonesia to the EU will require a legality licence (to be issued at the point of export). No imports to the EU without such a licence will be permitted. This will therefore provide a useful policy tool, that will support the existing initiatives being introduced by companies such as Carrefour, who are working towards providing evidence that all wood products used are, as a minimum, from a legal source. A supporting regulation is being reviewed by the Council and is expected to be passed towards the end of 2005. The development of VPAs and the accompanying action plans will then be instigated. Carrefour should keep abreast of the developments and ensure that their internal policies reflect and meet the policy objectives being developed at the EU and Member State levels.

[1] WWF/Global Forest Trade Network (GFTN) is a network linking groups of producers and buyers. Buyer groups have been formed in the UK, France, Italy and Spain for example, and producer groups exist in a number of producer countries including Indonesia. All buyers and producers are committed to legal and sustainable timber and wood products being produced and traded. The TFT is focused more on individual supply chains, linking buyers with their suppliers. Both schemes provide technical assistance to producers committed to supplying sustainable products.

Identified impact Possible instrument	Human health, land transformation, social issues, biodiversity and land erosion during teak log production Description	 Conditions and benefits	 Socio-economic considerations	 Recommendations
	assess the legality and sustainability of products in the supply chain. As part of the EU FLEGT Action Plan, Voluntary Partnership Agreements (VPA) will also be developed between producing countries and the EU (see footnote on previous page). Business to business approaches such as those used by Tropical Forest Trust and the WWF/GFTN framework[1], also provide a voluntary approach to ensuring sustainable and legal wood products.	licensing schemes developed under VPAs, because these schemes will be applied on a country-wide basis to all exports leaving the country. This provides a level of assurance of legality for producers and buyers, as the market now requires.	inherent interest in collective action to be taken by industry to reduce the volume of illegal product being sold at prices that undercut the legal suppliers. Industry across Europe is now working collectively to implement policies to mitigate the negative impacts of illegal products in the market. For example, a number of companies have signed an EU wide declaration.	implement similar approaches, for example via a specific activity under the IPP pilot project or though the establishment of a specific voluntary agreement at EU level (e.g. driven by EuroCommerce).
Consumer information	Growing consumer awareness, in part triggered by international NGOs, are responsible for increasing pressure on all parties in the forest products supply chain, including teak garden furniture. Consumers are often aware of the environmental issues concerned with teak production and of other tropical timber. In response retailers and suppliers are providing further information and labelling to consumers. With growth in internet and	Information on both generic issues and on company specific actions is readily available in the public domain. Companies need to be committed to providing information to the general public, to being transparent and open to both positive and negative comments related to all aspects of their supply chain. The key benefit of increased transparency towards final consumers is an increased awareness with the general public about the environmental	By encouraging transparency in their operations, positive socio-economic impacts will be felt throughout the supply chain. For example, issues surrounding human rights, infringement on local communities, access to land and resources, indigenous rights, are all topical issues that are high on the public agenda. Information surrounding these issues is more readily available and companies are more conscious of behaving in a responsible manner. Companies are aware that they need to provide information but	Carrefour and its factory in Indonesia, are working with WWF to operate a transparent system and make information available to the general public. Although teak, along with other tropical timber suffers from negative media coverage, it is a sustainable building and furniture raw material. The industry as a whole is now working collectively to promote the use legal and sustainable tropical timber. Providing proof of legality, obtaining certification, working

Identified impact Possible instrument	Human health, land transformation, social issues, biodiversity and land erosion during teak log production			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	media, consumers are more up to date than ever before on key issues surrounding tropical timber products and are able to react, through boycotts and substitution to other products. As consumers, timber importers in the UK stopped trading with Indonesia following a Greenpeace report at the beginning of 2004. Through discussions and close collaboration with suppliers, these buyers have now resumed trade.	and social issues involved in teak production. In certain cases, this might lead to a change in buying behaviour.	this does make them susceptible to negative press, sometimes more so than those that do not have such information readily and publicly available. Increased transparency could result in a better image for the company and possibly in increased sales. However, evidence shows that relatively few consumers are willing to pay significantly more for products with a better environmental and social performance.	publicly with NGOs and positively engaging with all stakeholders are key actions. Therefore we recommend that through its annual reports, media interactions, Carrefour should continue to work with consumer associations, media, NGOs and others, to ensure good information is readily available. This should include information about the wood sourcing practices. Other companies in the teak garden furniture chain should also be encouraged to increase their transparency related to social and environmental issues, for example via NGO pressure.
Forest charges and royalties	Forest operations typically pay a combination of an area tax and a volume-based tax. The area tax is based on a 'per hectare' value and the volume-based tax is based on annual extraction. Many countries have been reviewing such forest charges to incorporate the wider values that the forest resource provides that are not represented in the market place, such as carbon sinks,	Proper application of forestry-related charges depends among others on a clear definition of the environmental 'services' the forest delivers, good understanding of current practices and a thorough cost-benefit analysis. An analysis of the full costs of production – both the financial cost plus economic valuation of the wider impacts and value of the services provided by the	There is a growing recognition that forest charges and royalties have been historically too low. Provisions have been made to revise such taxes upward to reflect both the forestry department administrative and enforcement costs, as well as the wider environmental and social services that forest resources provide. Concerns exist over the financial sustainability or affordability of	Forest charges and royalties can be an excellent instrument to promote better management of forests and more attention to social issues. However, such instruments need to be properly designed and implemented by national authorities and set at the right levels to have the desired effect. The EU FLEGT programme,

Identified impact	Human health, land transformation, social issues, biodiversity and land erosion during teak log production			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	water quality, biodiversity, flood protection, etc. This has resulted in increases in such taxes from current low levels.	forest resource, is required. The forest charges should then be determined. For concessions forest charges are part of the operating costs ('paying the true price for the raw material'). The benefits of environmental taxation can be significant especially when applied over a longer period of time. Where area taxes are paid, concessions are assessing what size concession they can afford to run, given the size of the market and processing facilities they supply. In many countries forestry departments are seen as semi-government or parastatal and should be self-financing. Higher taxes are a key source of income for these departments.	the revised forest charges on an industry which in many places is already struggling to survive. The companies who pay their taxes are already finding it difficult to compete both nationally and internationally with those companies who avoid paying taxes. Thus higher taxes may act as a disincentive to act legally. The social impact is dependent on the redistribution of taxes. In Indonesia, PMDH is the community charge paid by forest concessions, which is based on profit and sometimes gives an incentive to companies not to make a profit to avoid paying such taxes. Another issue is the redistribution of tax revenues to local and district governments. Historically a high percentage of taxes on resources extracted at the district level are held at the national level.	and any resulting VPAs, could be a good instrument to assist third countries in designing and implementing a successful and fair charging system. Indonesia is likely to be one of the first countries that will develop a VPA, along with Malaysia, Ghana, Cameroon among others. However, care has to be taken not to infringe the national sovereignty of the countries involved.
Green public procurement	In line with EU procurement policy, a number of Member State governments (including the UK, France, Denmark, Germany and the Netherlands) are in various stages of developing public procurement policies for timber products. Legality of those products is often given as a condition of	With 20-40% of the timber consumption in the UK attributable to the public sector, timber procurement policy is a significant driver of change in the UK timber market and in the trade with supplying countries. As a result all suppliers are developing their own	The contract and variant specifications that comprise the public procurement policy cover both social and economic considerations. The explicitness of the social issues is dependent upon the interpretation of the EU procurement guidelines by each Member State. However, as certification is seen as the	It is therefore recommended that Carrefour develops a procurement policy that is compliant with the requirements of Member State procurement policies. The EU and individual Member States should make further efforts to implement

Identified impact	Human health, land transformation, social issues, biodiversity and land erosion during teak log production			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	contract and sustainability as a variant specification. To meet the contract and variant specifications, suppliers to the government will have to provide either: Type A evidence – certification schemes; or Type B evidence – other forms of evidence, that will need to be verified by a third party. Both forms of evidence require third party verification.	procurement policies and working towards improving their knowledge and relationships with their own suppliers – improving the information and cohesion along the supply chain from stump to end user. Suppliers to the government are responsible for ensuring that all timber and related products are as a minimum legal. Suppliers are therefore working to clean up their supply chains, obtaining third party verification and where possible certification. Public and private sector procurement policies, as well as codes of conduct, provide a commitment for all buyers to procure legal and sustainable products (sustainability incorporating environmental, social and economic components). This implies that throughout the supply chain, producers are conforming to international criteria and indicators for good forest management and the processing of wood based products.	preferred type of evidence required by Governments, social considerations will be positively influenced due to the social criteria within each of the main certification schemes. It will become increasingly difficult to supply the EU market without evidence of legality as a bare minimum. In the short term, a market premium is in existence for some products, although in the longer term, the incentive is to maintain market access and share rather than see a price premium. However, if illegal production can be removed from trade, the global prices should improve.	procurement policies that address these issues.
For generic tools see table 5.8				

Next to the tools described above there is one other 'instrument' that could be further developed. The lack of enforcement and the sometimes confused forest regulations in Indonesia, tend to create an environment that, to a certain degree, promotes illegal logging and over-harvesting. International pressure, for example by NGOs and the Consultative Group on Indonesia (CGI, which is collection of donor bodies operating in Indonesia) could play a significant role in ensuring that the government continues its commitments to sustainable forestry and the mitigation of illegal logging activities.

It is generally acknowledged that NGOs have been key drivers behind the development of the UK and other EU Member State public procurement policies, which in turn triggered the development of similar policies and codes of conduct in the private sector. The power of the NGOs was evident in the Greenpeace Indonesia report, which immediately following its release resulted in a number of significant UK traders ceasing to trade with Indonesia and alternative sources being found. Trade with Indonesia has resumed again but at a lower level. Several NGOs continue to provide a valuable role in both targeted campaigns and in public awareness, while others, such as WWF and TFT, play an important role of engaging with the private sector. The continuation of these activities should further increase consumer awareness related to the environmental issues of teak production.

Table 5.3 Assessment of possible instruments to address the significant environmental impacts during chair manufacturing

Identified impact	**Worker health and safety during chair manufacturing**			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
(Certified) Environmental, Health and Safety Management System	An EHS management system allows a company to systematically identify and address the key environmental, health and safety impacts during the manufacturing stage. Certification provides an additional, third party verification of the quality, implementation and results of such a system.	The implementation of an EHS management system requires at minimum the commitment of management and the allocation of sufficient resources over time. The key benefits of such systems lie in the systematic approach towards identifying and addressing the EH&S impacts of a specific operation. Moreover, they force companies to set up specific operational and reporting procedures which aim at ensuring	Typically, a proper EHS system improves the working conditions of employees and reduces the impacts of the manufacturing stage on the environment. While the implementation of such a system requires a certain amount of financial and human resources, the savings in terms of reduced illness, number of accidents, etc. can be significant. Also, EHS systems facilitate better and simpler compliance with legislation, reduced liabilities, and more cost-	As a major customer, Carrefour is in a good position to encourage the chair manufacturing facility to set up a formal EHS management system or to adopt good/best practice in this area. In fact, Carrefour claims to have chosen this particular supplier partly on the basis of having the ability to influence the company related to these issues. Therefore, we recommend Carrefour to continue to use its influence with this supplier to

Identified impact / Possible instrument	Worker health and safety during chair manufacturing			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
		continuous attention to these issues.	effective operations. Moreover, the attention to health and safety issues typically increases employee motivation with a positive impact on productivity.	help them improve their performance in this area and to encourage them to adopt a formal EHS system.
Voluntary agreements (Charters, Conventions, Pacts)	Many international public organisations (e.g. UN, WHO, ILO) and trade associations have established codes of conduct and best practice rules that aim to address social issues, specifically in developing countries.	For these voluntary agreements to be effective, they have to address the relevant social, health and safety issues identified. Moreover, companies signing up to such agreements need to adhere to the various requirements. To facilitate this, some sort of monitoring mechanism (e.g. through inclusion in the supplier auditing programme) could be established. The benefits of using such voluntary agreements are that, typically, companies sign up to basic principles and rules, after which the implementation can be done on an individual basis. This could result in a cost-effective approach but care has to be taken that actual results are achieved.	Adherence to such agreements may increase the costs of manufacture, for example due to improvements in working conditions, training and related capital investments. However, if adhered to properly such activities will undoubtedly improve working conditions and productivity may well increase as a result.	As a major customer, Carrefour is in a good position to encourage the chair manufacturing facility to adhere to a code of conduct on relevant social issues. Indeed, already in 1995 Carrefour began conducting social audits among its suppliers (DIY products, garments, footwear), which includes addressing working conditions. This initiative led to the formal signing of a Social Commitment Charter and to the creation of the INFANS association, in partnership with the International Federation of Human Rights (FIDH). Carrefour could extend the scope of existing supplier audits to cover adherence to such a code of conduct.
Eco-design	Environmental Product Development or Eco-design can be defined as the process by which environmental considerations are taken into account during the normal	The application of eco-design requires at a minimum a good understanding of the environmental impacts of a specific product and of the strategies for minimising that	'Designing out' the key impacts during teak chair manufacturing could result in significant improvements in worker health and reduce costs involved in sick days, accidents, etc.	Carrefour has design control over both the product and the packaging and has already undertaken actions in this area. Therefore, we recommend the continuation of these activities

Identified impact / Possible instrument	Worker health and safety during chair manufacturing			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	product development process. Eco-design can be undertaken on an ad-hoc basis (e.g. for a specific product range) or as an integral part of the product design process (i.e. for each designed product). There are many different eco-design 'strategies' aimed at reducing the environmental impacts of products throughout their life cycle, including design for energy efficiency, design for recycling, design for disassembly, minimising materials use, minimising hazardous materials, etc.	impact, which in turn requires a detailed understanding of the production process. Eco-design could bring significant improvements to worker health and safety during chair manufacturing, for example through 'designing out' hazardous materials used in the chair and during production (brass fastenings, glue, etc.), and reducing the amount of wood cutting operations thereby minimising dust.	Typically, eco-design efforts also result in reduced energy use and increased material efficiency which often results in cost savings. However, companies need to invest in eco-design for example by recruiting qualified designers, doing LCAs and building up a good understanding of the environmental impacts of the product.	with a focus on the potential health impacts of chair manufacturing processes.
For generic tools see table 5.8				

Table 5.4 Assessment of possible instruments to address the significant environmental impacts during distribution

Identified impact / Possible instrument	Non-renewable energy use during distribution			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
Eco-design	Environmental Product Development or Eco-design can be defined as the process by which environmental considerations are taken into account during the normal product development process. Eco-design can be undertaken on an ad-hoc basis (e.g. for a	The application of eco-design requires at a minimum a good understanding of the environmental impacts of a specific product and of the strategies for minimising that impact. Moreover, the company should ideally have design control over the product and	Reducing product and packaging weight and volume typically reduces the transportation cost and could be considered a classical win-win situation. However, care has to be taken not to overdo product weight	Optimising the product and packaging weight and volume is an excellent way of reducing energy use during transport, as well as reducing distribution cost. Carrefour has design control over both the product and the

Identified impact	Non-renewable energy use during distribution			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	specific product range) or as an integral part of the product design process (i.e. for each designed product). Many different eco-design 'strategies' can be distinguished, including design for energy efficiency, design for recycling, design for disassembly, minimising materials use, minimising hazardous materials, etc.	the applied eco-design strategies would have to be focused on optimising product and packaging weight and volume. Lower weight and smaller volume (i.e. of the folded chair plus packaging) reduces the environmental impact of the distribution phase per individual chair, as less weight has to be transported and more products can be shipped in one go (e.g. more chairs would fit in 1 container or on 1 pallet).	minimisation as this could result in a lower quality product with a shorter life-time. Moreover, packaging reduction could result in more damage to the product during transport, and subsequently more product waste. Less impact during the distribution phase has an immediate effect on human health through reduced emissions (e.g. CO2, particulate matter, heavy metals, etc.)	packaging and has already undertaken actions in this area. Therefore, we recommend the continuation of these activities to ensure possible further improvements.
Logistics planning	Logistics planning typically involves a variety of different activities including planning and choice of transport mode, optimisation of distances travelled and minimisation of empty trips/optimisation of container capacity, both on outbound and return journeys.	Planning of logistics provides an opportunity to minimise the distances travelled to market and the fuel use (and consequent CO2 burden) during distribution, with an immediate positive effect on the environment impacts. It is likely that there will be transfer between modes at different points (e.g. from road/rail to container ship, and back to road/rail). As a minimum, companies need to have control over the distribution chain.	Less impact during the distribution phase has an immediate effect on human health through reduced emissions (e.g. CO2, particulate matter, heavy metals, etc.). Typically, reduced distribution efforts result in reduced cost, although there may be trade-offs between speed of delivery and environmental impact. However, international distribution chains are largely driven by cost considerations which may reduce the opportunity to specify environmental requirements.	Carrefour should investigate options for reducing distances travelled; optimising use of containers; and using transport modes with lower CO2 emissions (e.g. rail not road transport from port to distribution hub). Member State governments can facilitate use of environmentally friendly modes through use of eco-taxes and land use planning policy.
Packaging standards	Packaging standards are typically used to specify fitness-	Minimisation of materials may help to reduce the impact of the	Less impact during the distribution phase has an	Carrefour has design control over the packaging of the teak

Identified impact / Possible instrument	Non-renewable energy use during distribution			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	for-use and safety criteria. Environmental parameters have recently been established as well via the EU Packaging and Packaging Waste Directive. These standards address the prevention of packaging, reusability, recycling, organic and energy recovery.	packaging itself. The minimisation of packaging volume will enable optimisation of distribution capacity, for example by allowing more products to be shipped on one pallet or in one container. Light weighting of packaging will also lead to benefits in terms of reduced fuel consumption during distribution. As a minimum, companies need to have packaging design control and have a good understanding of the environmental impact of packaging materials.	immediate effect on human health through reduced emissions (e.g. CO2, particulate matter, heavy metals, etc.). Less packaging material will also lead to reduced charges under the EU Packaging and Packaging Waste Directive. However, there will be a trade-off between light weighting and the need to provide adequate protection to the product.	garden chair and should apply the relevant packaging standards, specifically those related to packaging prevention. These standards should be interpreted in a strict way to minimise packaging use as far as possible.
For generic tools see table 5.8				

Table 5.5 *Assessment of possible instruments to address the significant environmental impacts during use*

Identified impact / Possible instrument	Water use during use			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
Consumer information on product care and maintenance	Providing clear information to consumers related to the proper care and maintenance of any product is a good way of informing them, not only about what they should do in this	Information needs to be provided in an easily accessible, user-friendly and trustworthy format. Consumers may be reluctant to read information if	Providing good care and maintenance information to consumers should not be hugely expensive and can help in conveying a quality image of the	Carrefour, and other companies selling similar products, should provide clear, easily understandable and consistent information to consumers through multiple channels,

Identified impact / Possible instrument	Water use during use			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	context but also about the environmental effects of good care. An information leaflet included with the product is only one way of conveying this information. Other means of communication will include consumer magazines, web pages, television programmes, and other 'opinion-formers'. Ideally, consumer information should be clear, easy to understand and easily accessible.	this is not the case. The key benefits of proper consumer information in this context are a reduced environmental impact during the use phase as well as a possible extension of the product lifetime.	product and the company. Reduced water use will also reduce the cost of maintenance although this is likely to result in minor savings only. It will be important to encourage consumers not to use other ways to clean and protect the product such as solvent-based cleaners, paints, varnishes and oils, as this would negatively influence the environmental impact of the chair.	possibly in partnership with environmental and consumer NGOs. This information should address not only how to properly take care of the product but also that not doing this could result in significant environmental (and possibly health) impacts. Environmental and consumer NGOs could be paying more attention to the use phase of products, for example via their newsletters, magazines and other public awareness raising campaigns.
For generic tools see table 5.8				

Table 5.6 Assessment of possible instruments to address the significant environmental impacts during end-of-life

Identified impact / Possible instrument	Human health, land transformation, biodiversity and land erosion during end-of-life			
	Description	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
Waste legislation (e.g. on landfill, incineration, recycling, etc.)	Waste legislation consists of a broad range of regulations, including requirements for product take-back and recycling, requirements for the management of waste (e.g. well managed landfill, controlled incineration), and targets or incentives to increase recycling	Waste legislation would need to address the specific product under consideration. Proper waste legislation could result in a reduced environmental impact of the end-of-life stage of the teak garden chair, for example by	Separate collection of teak chairs is likely to be impractical due to lack of quantity. Moreover, producer responsibility for this product would most likely be disproportionate to the environmental impacts caused at end-of-life and too costly.	The Landfill Directive places obligations on Member States to reduce the quantity of municipal bio-degradable waste sent to landfill. It may be recommendable for Member States to look at options for diverting wood waste from

Identified impact	Human health, land transformation, biodiversity and land erosion during end-of-life			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	and divert waste from final disposal such as through taxes.	encouraging product re-use, separate collection and proper recycling and/or disposal. Separation of wood waste from other waste fractions could facilitate recycling and, if this is not possible, controlled incineration with energy recovery.	The longevity of the wood and the inherent value of products at end of life may support a market in second-hand teak furniture for refurbishment and resale/reuse.	landfill, e.g. by encouraging reuse, separate collection and recycling, and incineration with energy recovery. For example, Germany introduced a Waste Wood Ordinance (which came into force in March 2003) that no longer allows the landfilling of wood waste and puts in place requirements for proper end-of-life management.
Consumer information	Consumer information can be used to create awareness about the environmental impacts of the end-of-life stage of products as well as about the proper way of disposing of them.	A key condition for allowing consumers to act responsibly at the end of life of the teak garden chair is the availability of take-back and recycling systems for this product. Lack of such systems would most likely result in cynicism with consumers about the usefulness of the information provided to them.	Good information on, and available systems for, the separate collection and recycling of wood products would encourage a positive attitude to broader waste recycling and the environment. However, the establishment of such systems could be relatively costly and may be disproportionate to the achievable benefits.	At a minimum, Carrefour should inform consumers about the possible environmental impacts of the teak garden chair at end of life, and the ways for minimising those impacts (e.g. by encouraging reuse or recycling). Member States could look at options for informing the general public about these impacts, end-of-life options and the actions consumers can take to re-use or recycle wooden products.
For generic tools see table 5.8				

Table 5.7 Assessment of possible instruments to address the significant environmental impacts through life-time extension

Identified impact	**All significant impacts through life-time extension**			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
Product guarantees	Product guarantees typically give certain rights (repair, reimbursement of costs, replacement) to the buyer of a product in case of defects, breakdowns, etc. They are usually limited in time. Often a distinction is made between a legal and commercial guarantee, whereby the later indicates any additional undertaking given by a seller or producer, over and above the legal rules governing the sale. The EU adopted in 1999 a specific Directive[1], which lays down a common set of consumer rights valid no matter where in the European Union the goods are purchased. Central amongst these is that if goods are defective, or do not conform with the contract agreed at the time of purchase, consumers have a right of redress against the seller for two years after taking delivery of the goods.	The available product guarantee needs to be sufficient to encourage life-time extension, which for products with a long lifetime is often difficult. Extending the life-time of most products has a direct, positive impact on their environmental performance, as the environmental impacts are spread of a longer period of time and replacement takes place later.	Offering extensive product guarantees comes at an additional cost to the consumer, typically in the form of a higher product price. Most consumers will not be willing to pay for this premium and will choose (if there is a choice) for the minimum guarantee (i.e. 2 years in the EU). An extended product guarantee tends to send an increased quality message to consumers. While this in itself does not need to pose a problem, it might not fit with the position of the teak garden chair in the entire Carrefour portfolio of garden furniture.	Carrefour already offers a guarantee of 5 years on the teak garden chair, going beyond the legal requirements in the EU. Carrefour could consider extending this guarantee, for example at an additional cost for the consumer, but the added value and cost need to be carefully assessed upfront.

[1] Directive 99/44/EC of the European Parliament and of the Council of 25 May 1999 on certain aspects of the sale of consumer goods and associated guarantees

Identified impact Possible instrument	All significant impacts through life-time extension Description	 Conditions and benefits	 Socio-economic considerations	 Recommendations
Availability of spare parts	Availability of spare parts allows for the repair and maintenance of a product and is typically linked with any available product guarantee. Alternatively, eco-designing the product may result in the possibility to maintain and repair the product using widely available spare parts, as opposed to proprietary or bespoke ones.	A key condition is that the cost of having spare parts available does not outweigh the benefits of keeping the product in use. For some products, straight replacement would be considered the best option. The availability of spare parts allows products to be maintained and repaired throughout their use phase thereby extending their life-time and reducing the environmental impacts of the chair.	Developing a system to ensure that necessary spare parts are available throughout the lifetime of the product will be costly and could result in a higher product price. Product owners would need to be signposted to the source of spare parts and spare parts need to be easily available.	As it may be more effective (i.e. less costly and more user-friendly) to encourage product design that facilitates maintenance and repair with a wide range of non-proprietary fittings and fastenings, Carrefour could be recommended to explore this route further.
Consumer information	Consumer information can be used to create awareness about the environmental effects of the life time extension of products.	A key condition for allowing consumers to act effectively towards extending the life of the teak garden chair is the availability of spare parts and a straightforward way for repairing the product, either by themselves or via a dedicated repair centre. Lack of these would most likely result in cynicism with consumers about the usefulness of the information provided to them.	Good information on, and availability of, repair options would result in the garden chair being used longer and therefore a reduced need to buy a replacement. However, this might in some cases conflict with the desire of companies to sell more of the same products. It could also result in higher product price to cover the additional service of having spare parts available for a longer period or in a higher cost price for the spare parts themselves.	At a minimum, Carrefour should inform consumers about the possible environmental effects of an increased lifetime of the teak garden chair, and the ways for increasing the lifetime (e.g. how to repair the chair). Member States could look at options for informing the general public about these impacts.
For generic tools see table 5.8				

Next to the above-outlined specific instruments, there are a number of more generic tools that can be applied to address the environmental impacts across the entire life-cycle of the teak garden chair. These are assessed in the table below.

Table 5.8 *Assessment of possible generic instruments to address the significant environmental impacts across the entire life-cycle*

Identified impact	All significant impacts across the entire life-cycle of the teak garden chair			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
Eco-labels	Eco-labels are voluntary instruments which allow consumers to identify products with a reduced environmental impact. Eco-label criteria typically address a number of environmental (and sometimes health) impacts of a specific product. Companies can apply for the label and have to show their product complies with the relevant criteria before being allowed to put the label on the product. In the EU there are a number of eco-labels including the EU Eco-label, the Nordic Swan, the Blue Angel and several others.	Eco-label criteria for (wooden) furniture need to be in place. These criteria (EU Eco-label criteria for wooden furniture are currently being developed) should require the producer or retailer to address the various environmental impacts (e.g. related to sustainable forest management, consumer maintenance and care instructions, disposal, etc.). The benefits of the use of eco-labels depend largely on the willingness of companies to apply for the label (i.e. the number of products complying with eco-label criteria) and of consumers to buy labelled products. Next to this, the criteria should be realistic and effective. There is limited hard data on the direct benefits of eco-labels, although indirect evidence indicates that companies do use the criteria for product development and	Complying with eco-label criteria can in certain cases be rather resource intensive. Next to the need for changing the product itself, it sometimes requires product testing and in all cases a fee needs to be paid. However, these costs could be offset by increased sales, especially if the eco-label confers a message of quality and inspires confidence with consumers. Nevertheless, in practice, many companies have shied away from applying for an eco-label, citing costs and a lack of consumer interest as main reasons.	The EU is currently in the process of developing an eco-label for wooden furniture and Member States and the Commission should ensure all relevant impacts are addressed in the criteria. For wooden furniture this should as a minimum address sustainable forest management practices, treatment of the product during use and consumer information. Once the criteria have been established they need to be promoted by the Commission, the Member States and other stakeholders to encourage companies to apply for the label. Carrefour, and other companies, should consider applying for the label. Additionally, consumer and environmental NGOs should consider promoting eco-labels for furniture products through their various communication channels.

Identified impact Possible instrument	All significant impacts across the entire life-cycle of the teak garden chair Description	 Conditions and benefits	 Socio-economic considerations	 Recommendations
		benchmarking even if they do not apply for the label itself.		
Eco-taxes	Taxes on inputs or outputs - also known as eco-taxes – are often used to signal the costs of using the environmental resources and thus internalises the negative externalities in decision making by producers and consumers. An eco-tax is a price-like instrument, which assigns a price to the 'unpaid factor' of production, thus translating the polluter pays principle in practice. There are many types of environmental taxes including input taxes, output or product taxes, export taxes, import tariffs, land-use taxes, tax differentiation, royalties and resource taxes and investment tax credits.	Proper application of eco-taxes depends among others on a clear definition of the environmental objectives of the measure, good understanding of current practices and a thorough cost-benefit analysis. The benefits of environmental taxation can be significant especially when applied over a longer period of time. Evidence has shown that this is especially true for reducing energy consumption, but has also been shown to result in fuel-switching in the case of differential tax rates for competing energy sources. Also taxes on landfill, water use and packaging have been shown to be effective, although to varying degrees depending on the way they have been implemented.	The use of taxation for environmental purposes is widespread, accounting in revenue for roughly 2% of GDP in OECD member countries. Application of environmental taxation is rather complex and research by the OECD has shown that there are large differences in practice and effectiveness depending on the type of tax and the application area (e.g. energy, waste, water, etc.). Two key socio-economic concerns related to eco-taxation are the possible impact on international competitiveness of the most polluting, often energy-intensive sectors of the economy, next to the potential higher impact of some taxes on lower-income households.	Eco-taxation could be a useful tool to address the environmental and social impacts of the teak garden chair. However, care has to be taken in designing and implementing such tools, as was already highlighted in table 5. 2. If properly designed, the most effective areas for the application of taxes would be teak log production, distribution and end-of-life.
Green Public Procurement	With public procurement spending accounting for around 15% of GDP in the EU, the so-called 'greening' of public procurement is often seen as a good way to improve the environment performance of products. This can be done by adding environmental criteria	A key condition is that environmental and social procurement criteria need to be established for furniture and that procurers need to apply these criteria in their purchasing processes. Criteria have been applied	The key economic consideration with green public procurement is the focus on price as a key condition during purchasing. This will sometimes result in de-selection of products with a higher environmental performance due to a higher	Member States should explore the options for including environmental criteria into their purchasing processes for teak garden furniture (see the section on green public procurement in table 5.2). The EU eco-label criteria (once

Identified impact	All significant impacts across the entire life-cycle of the teak garden chair			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
	to the normal purchasing processes used across the public sector (e.g. product specifications, selection of suppliers), in conformity with the EU public procurement Directives.	successfully to many different product categories at the level of national, regional and local government in many Member States, so there does not seem to be a fundamental hurdle to applying them to garden furniture.	product price. However, with the increased focus on life-cycle costing this might benefit products that require less maintenance during their lifetime (such as teak garden furniture).	adopted) could be used to facilitate this process.
Green corporate procurement	As a result of the implementation of environmental management systems and under influence of the Corporate Social Responsibility framework, many companies have been 'greening' their purchasing behaviour. Corporate procurement is typically divided between sourcing raw materials and components for production purposes and purchasing auxiliary materials for support functions (e.g. office equipment and supplies).	The benefits of integrating environmental criteria into corporate procurement processes can be manifold, including compliance with legislation, competitive advantage, better product quality, improved corporate image, lower operating costs, etc. However, of key importance to a successful corporate green procurement programme is the commitment of senior management. This needs to go beyond the establishment of a policy and will have to involve allocation of resources, training of procurement staff, establishment of criteria and targets, implementation of procedures and control activities, etc.	As with public procurement, there is often the perception that 'greener' products are more expensive. Another concern is the availability of sufficient, quality supplies, which has for example hampered the development of markets for recycled plastics. On the other hand, the increased focus on life cycle costing means that products can have a lower overall cost. Next to this, the use of 'greener' products can result in improved working conditions (e.g. less toxic chemicals in production, better office environment), less sick leave and more motivated personnel.	Companies buying teak (garden) furniture (e.g. restaurants, hotels, conference centres) could be persuaded to include environmental criteria into their purchasing procedures for these products. This could be done via targeted campaigns undertaken by governments, NGO's or companies supplying such products to the market. The EU eco-label criteria (once adopted) could be used to facilitate this process.

Identified impact / Possible instrument	All significant impacts across the entire life-cycle of the teak garden chair			
Possible instrument	**Description**	**Conditions and benefits**	**Socio-economic considerations**	**Recommendations**
Corporate reporting	Annual reporting targets are a key part of many company CSR and environmental policies. Companies that for example have signed up to the UK TTF Responsible Purchasing Policy or the Global Reporting Initiative are required to report on progress on an annual basis, against targets. On the teak log production side, forest concessions are required to prepare an annual forest management plan, against which volumes extracted, taxes and environmental and social impacts can be assessed. Typically, targets are set for all phases of the product's life cycle, from raw material production and product manufacturing, through to the use phase (e.g. on energy efficiency) and end-of-life.	All players in the supply chain have to be committed to providing information into the public domain, being open to scrutiny, and to operating in a transparent manner. Companies need to have a systematic approach to reporting, based on embedded internal procedures, relevant targets and the application of sufficient resources. The benefits of reporting are that companies can be checked on progress against their, often self-established, targets, thereby holding them to account and 'forcing' them to make efforts to meet their targets. Many CSR and environmental reports are verified by third parties.	Transparency of information means that any potential negative social impacts can be identified and addressed. This is one of the main objectives of externally verified management systems including those related to sustainable forestry and EHS. However, transparency and reporting comes at a cost (largely due to the need to have robust underlying systems that allow proper management of the relevant issues) and this will often translate into higher product prices. It is therefore important that a level playing field is established, for example via sector wide agreements or legislation.	It is recommended that Carrefour continues to report on all aspects of the product chain for its teak garden chair, in its annual and environmental reports. Being able to provide the evidence that all timber used is from legal and sustainable sources is now a key condition of trade with the EU. It is also important in meeting the demands of NGOs in this area. Such reporting will also assist Carrefour in its justification for not buying the cheaper sources of teak and in maintaining its presence in the market.

5.3 *CONCLUSIONS*

Based on the identification of the key environmental impacts under task 3 and the above-outlined instruments for mitigating these impacts, the following key conclusions can be drawn:

- The use of certified forest management systems is most likely the best tool for reducing the environmental impacts associated with teak log production. This should be assisted by the EU's FLEGT programme and other international initiatives in this area, such as the CGI process and campaigning activities by NGOs. The current activities undertaken by Carrefour related to

the teak supply chain are commendable and provide a good basis for further efforts in this area. Greater consumer awareness of these issues would also increase the pressure on retailers, distributors and manufacturers to implement sustainable forest management practices.

- The application of eco-design tools and strategies is an excellent way to address a number of other product impacts including waste minimisation and process optimisation during chair manufacturing, product and packaging weight and volume optimisation for more efficient distribution, and increased product quality and repairability to extend the product lifetime. Again, Carrefour has already started to address some of these issues via the use of eco-design principles, although these could probably be extended.
- Finally, a promising instrument to mitigate the impacts related to the use phase, end-of-life and lifetime of the teak garden chair is the use of consumer information. More extensive use of clear and easily understandable information should encourage consumers to maintain and repair their products properly and thus extend their lifetime. It will also allow for the provision of information about the best end-of-life options for the teak garden chair, although there would be a need for Member States to ensure proper collection, recycling and disposal systems are in place. Consumer awareness raising could also be used to promote teak garden chairs as valuable items of furniture that last a lifetime. Such information should not only be provided via the user manual or instructions but ideally via a broad selection of media including the internet, advertising, in-store information and NGO endorsements.

The other instruments highlighted in the tables will be useful as well and can be deployed in conjunction with the key instruments mentioned above.

5.4 *FINAL CONSIDERATIONS*

While many of the proposed instruments will have a significantly positive impact on the environmental performance of the teak garden chair, implementing these instruments will often have an additional impact on the product cost, at least in the short term. Forest certification, EHS management systems, eco-design efforts, additional consumer information, the availability of spare parts, etc. will probably add to this. Although some of these costs will be offset by cleaner manufacturing processes, lower resource use and more efficient distribution, the final result will most likely be a higher product price.

So far there seems little evidence that the market is willing to pay a price premium for teak garden chairs with a significantly reduced environmental impact, which means the efforts to further improve these impacts (many of which are already undertaken by Carrefour) are currently not being rewarded through increased sales for these products. There will most likely be two main ways of addressing this market 'failure':

Carrefour could decide to turn this teak garden chair into what could be called an environmental 'flagship' product. By improving and promoting the overall quality of the product (including a long lifetime) and superior environmental performance (including the use of legally sourced teak), the garden chair could be positioned as a top of the range product. By doing this, the higher product cost could be justified and this might be attractive for certain consumers. This effort will need to go hand-in-hand with a broader campaign to sensitise consumers (and possibly the general public) about the effects of illegal logging on social conditions in certain countries, thereby enhancing the appreciation with potential buyers of the efforts needed to produce a 'clean' chair. Member States, NGOs and consumer associations would have an essential role to play in this context, as information by the company alone might not overcome existing scepticism. However, one has to bear in mind that this will most likely only result in a 'niche' market for this type of product, as currently not many consumers are willing to pay significantly more for superior (environmental) performance.

Secondly, both Member State governments including the European Commission, as well as the governments of countries where teak is produced, could do more to ensure a level playing field for companies in this area. As long as products containing illegally sourced wood can relatively easily find their way onto the EU market, a significant price difference will continue to exist between furniture made of illegal and legal teak, thus discouraging consumers to buy the 'better' products. This situation distorts competition and acts as a break on further and broader product improvements. While significant efforts are under way to address this issue, for example via the EU FLEGT process, the various national procurement policies and NGO activities 'on the ground', more efforts are needed to encourage and enforce better controls on illegally sourced teak.

Both 'strategies' could obviously be pursued simultaneously and are not necessarily mutually exclusive. However, once better controls are in place and no or little illegal wood finds its way unto the EU market, price differences should become smaller and the 'flagship' approach might be less effective.

It is in this context that the IPP approach could prove to be a catalyst for changes in the product chain. By encouraging a variety of stakeholders to play specific roles in a concerted effort to improve the overall environmental performance of the teak garden chair, the market as a whole could both be pushed (e.g. via the EU FLEGT process and NGO pressure) as well as pulled (e.g. via more and better information for consumers) into the desired direction. The simultaneous application of several instruments (as outlined in the tables) would facilitate such a development, bearing in mind that some of these could be implemented relatively quickly (such as better consumer information in product leaflets), while others need more time to give the desired results (for example the VPA with the Indonesian government). In this way, the IPP approach would provide real added value to environmental policy development in specific product sectors.

Annex A

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Annex B

Stakeholder Consultation

IPP PILOT PROJECT ON A TEAK GARDEN CHAIR
EUROPEAN COMMISSION

Introduction

All products cause environmental degradation in some way, whether from their manufacturing, use or disposal. In order to try and minimise this environmental impact, the European Commission has developed a new, product-oriented environmental policy strategy, called 'Integrated Product Policy' (IPP). The IPP approach involves looking at all phases of a product's life cycle and taking action where it is most effective.

As part of the IPP strategy, the Commission has initiated two innovative pilot projects, to deliver hands-on experience of how IPP can work in practice. Carrefour's teak garden chair has been selected as one of these pilot projects and Environmental Resources Management (ERM) are working in conjunction with Carrefour and the European Commission to carry out the project.

One of the main tasks in this project, is the collection of information related to the environmental impact of a teak chair throughout its life cycle from a wide range of stakeholders. This covers all stages, from the production and harvesting of teak, through processing, manufacturing of fixtures and fittings, chair assembly, packaging, distribution, retail, use and eventual disposal. The information will be used to assess the environmental impacts associated with each life cycle stage and identify improvement options.

This study is very important for the future development of IPP. The success of the pilot projects is seen as critical to establishing a practical framework for its application in the EU. For further information regarding IPP, and the pilot projects, please see http://europa.eu.int/comm/environment/ipp/implementation.htm.

Questions

In this context, the headline questions to which we would like to obtain answers are:

- What do you consider the key environmental impacts of a teak garden chair?
  (This would include, amongst others, issues related to forestry, chair production, transport, use, maintenance, disposal, etc.)

- Could you provide us with data related to these environmental impacts?
  (This would include, amongst others, data related to the use of electricity, chemicals, fossil fuels, emissions to air, water and soil, impacts related to transport, etc.)

- Do you know any other organisation or person we should be talking to, to obtain further information?

LIST OF CONSULTED STAKEHOLDERS

Organisation	**Person contacted**
Working-group: Sustainability in the Wood Processing Industry	Hans-Heinz Seyfarth
OVAM	Wouter Ulburghs
IKEA	Lotta Malfrere
HOMEBASE	Charles Drewe, John Barrett
B and Q	Annie Johnson
Carrefour	Nicolas Regouby
Joanneum Research/COST Action 31	Gerfried Jungmeier
European Furniture Manufacturers Association	Secretariat
Food and Agricultural Organisation	Wulf Killmann
CEI-BOIS	Frederik Lauwaert, Chris van Riet
WWF France	Emanuelle Neyroumande
WWF Belgium	Dominiek Plouvier
ProForest	Ian Gray

Organisation	Person contacted
UK Timber Trade Federation	Andy Roby
Tropical Forest Trust Indonesia	Dejan Lewis, Ben Jarvis
Imperial College London	Richard Murphy
CIFOR	Philippe Guizol
Smartwood (FSC accredited auditors of PT Perhutani)	Jeff Hayward
Dutch Timber Trade Association	Paul van den Heuvel
Pro Natura	Guy Reinaud
FIRA International Ltd.	Alun Watkins
SGS International	Antoine de la Rochefordiere
Indonesian Forum for Environment	Helvi Lystiani

Annex C

Qualitative Scoring

1 INTRODUCTION

To provide a common basis across the assessment there is a need for all the environmental issues to be assessed on a numerical basis as this will allow comparison and conclusions to be drawn. For some of the environmental issues identified by stakeholders there is currently no data or, in some cases, methods for quantifying the actual scale of the impact associated with the teak chair. In the absence of these methods having been applied the pilot project was required to determine whether consideration and management of a products life cycle is feasible without detailed assessments having been conducted. It has therefore been necessary to develop a consistent approach to scoring the teak chair performance with regard to these qualitative issues. The qualitative scoring method was developed to mirror the approach for the quantitative impacts (such as GHG potential).

The scoring system is based on an assessment of four key components:

- level of concern with this type of industrial process for this issue;
- level of management by process owner,
- scale of particular operation; and
- the weight of the material flow attributable to this product.

These components are scored by using a series of statements or measures that represent high, medium or low risk. These scores are subsequently multiplied by the weight of the material flow under investigation to proportion the contribution of the activity (e.g. brass production) to the entire product. In this way, the contribution of a small component (e.g. the glue) is given less weight than that of a large component (e.g. the wood). This approach reflects the ethos of the quantitative approach in that the impact contribution that arises from a specific industry sector is allocated to the teak chair.

The table below provides an example:

Level of Concern with this type of Industrial Process for this issue	
Measure	**Score**
High concern (UNEP/WHO/WWF/Governmental Programme)	3
Medium/low concern (Awareness/identified as posible issue but no obvious programmes)	2
No concern	1
Score given for level of concern	**2**

Level of management by process owner	
Measure	
No management	3
Low/medium level of manangement (considered to be low level of risk/harm)	2
High level of management (certification/licenses/monitoring/ managed to no harm/low risk level)	1
Score given for level of management	**2**

Scale of particular operation	
Measure	
Large scale/major inustrial/economic activity	3
Medium scale industrial/activity activity	2
Small scale industrial/economic activity	1
Score given for scale	**2**

Weight of material flow (kg)	**1**

Combined Score	8

Such tables have been established for each of the following life cycle phases against each of the non-quantifiable impact categories:

- Teak (log) production
- Brass Fastening production
- Oil/lubricant production
- Sand Paper Production
- Packaging material production
- Teak Component Manufacture
- Chair Assembly
- Distribution

- Use
- End of life

1.1 QUALITATIVE SCORING RESULTS

Table 1.1 details the qualitative impact values determined across the life cycle of the teak chair. These are presented in *Section 3.1.3* of the report as a percentage contribution of each life cycle stage, or activity, to the total impact in each category.

Table 1.1 Qualitative Scoring Results

	Human Health	Land Transformation	Social Issues	Biodiversity	Erosion
Teak (log) production					
Level of Concern	2	2	3	3	3
Level of management	1	1	2	1	1
Scale of Operation	3	3	3	3	3
Weight of component	12.17	12.17	12.17	12.17	12.17
Total	73.02	73.02	219.06	109.53	109.53
Brass fastening production					
Level of Concern	3	3	3	3	3
Level of management	2	2	2	2	2
Scale of Operation	2	2	2	2	2
Weight of component	0.1	0.1	0.1	0.1	0.1
Total	1.2	1.2	1.2	1.2	1.2
Glue production					
Level of Concern	3	3	3	3	3
Level of management	2	2	2	2	2
Scale of Operation	2	2	2	2	2
Weight of component	0.031	0.031	0.031	0.031	0.031
Total	0.372	0.372	0.372	0.372	0.372
Oil/lubricant production					
Level of Concern	3	3	3	3	3
Level of management	2	2	2	2	2
Scale of Operation	2	2	2	2	2
Weight of component	0.01	0.01	0.01	0.01	0.01

	Human Health	Land Transformation	Social Issues	Biodiversity	Erosion
Total	0.12	0.12	0.12	0.12	0.12
Sand Paper Production					
Level of Concern	3	3	3	3	3
Level of management	2	2	2	2	2
Scale of Operation	2	2	2	2	2
Weight of component	0.1	0.1	0.1	0.1	0.1
Total	1.2	1.2	1.2	1.2	1.2
Packaging material production					
Level of Concern	3	3	3	3	3
Level of management	2	2	2	2	2
Scale of Operation	2	2	2	2	2
Weight of component	0.33	0.33	0.33	0.33	0.33
Total	3.96	3.96	3.96	3.96	3.96
Teak Component Manufacture					
Level of Concern	2	1	1	1	1
Level of management	2	1	1	1	1
Scale of Operation	2	1	1	1	1
Weight of component	6.08	6.08	6.08	6.08	6.08
Total	48.64	6.08	6.08	6.08	6.08
Chair Assembly					
Level of Concern	1	1	1	1	1
Level of management	2	1	1	1	1
Scale of Operation	1	1	1	1	1
Weight of component	6.23	6.23	6.23	6.23	6.23
Total	12.46	6.23	6.23	6.23	6.23
Distribution					
Level of Concern	3	3	3	3	3
Level of management	2	2	2	2	2
Scale of Operation	2	2	2	2	2
Weight of component	6.23	6.23	6.23	6.23	6.23
Total	74.76	74.76	74.76	74.76	74.76
Use					
Level of Concern	1	1	1	1	1

	Human Health	Land Transformation	Social Issues	Biodiversity	Erosion
Level of management	1	1	1	1	1
Scale of Operation	1	1	1	1	1
Weight of component	6.23	6.23	6.23	6.23	6.23
Total	6.23	6.23	6.23	6.23	6.23
End of life					
Level of Concern	3	3	3	3	3
Level of management	1	1	1	1	1
Scale of Operation	3	3	3	3	3
Weight of component	5.9	5.9	5.9	5.9	5.9
Total	53.1	53.1	53.1	53.1	53.1

1.2 JUSTIFICATION OF QUALITATIVE SCORES FOR TEAK PRODUCTION

In general, there are several environmental impacts associated with teak plantations. These include:

- Teak as a pioneer species, is generally susceptible to competition from other plant species, thus the management practice often includes the clearing of undergrowth and debris. This practice aids teak growth in the short term but will inevitably result in longer-term site degradation.
- Through the clearing of undergrowth (through litter raking, excessive burning, etc), the soil is exposed to the elements and this may exacerbate erosion and leaching of the soils, leading to degraded soil quality and fertility. This is further enhanced through the wide tree spacing in plantations and the large leaf size, prone to leaf drip.
- Intercropping in the year immediately following clear felling, by local communities with agricultural crops helps to reduce the impact of erosion, which is predominantly in year 1 out of an 80-year cycle.
- Where good management practices are used, buffer zones around water courses and biodiversity areas are used.

Typically, most environmental criticisms directed at teak plantations are the result of inappropriate management rather than irrevocable plantation characteristics. Ultimately, the level of impact depends on the quality of the forest or plantation management and the supporting chain of custody procedures applied. Good forest management or sustainable forest management will apply management practices that maintain a sustainable source of timber supply while minimising the impact on the environment including biodiversity, water courses, soil erosion and on any land transformed from alternative land use practices. In addition, sustainable forest management as defined in criteria and indicators of certification schemes such as the FSC, MTCC, PEFC, etc, includes minimising social impacts on neighbouring communities and maximising the economic benefit to society of the plantation. Rigorous chain of custody tracking systems ensure that the final product can be traced back to the

stump in the plantation and all management practices along the chain can be assessed for legality and sustainability. The following justifications are based on the practices observed for the production of this specific teak chair from Carrefour.

1.2.1 Land Transformation & Sustainability

Land conversion for plantations is potentially a very significant negative impact with natural forest being rapidly depleted for conversion. However, Perhutani teak plantations have existed for more than 100 years. New clearings are on a relatively small scale and predominantly by community producers who supply to the Jepara region.

The rate of transformation of land, which can include the impact of land use, will depend on the management practices applied. Some districts of the Perhutani plantations are working towards certification with the Tropical Forest Trust (TFT) and WWF/GFTN group. The mill supplying Carrefour with furniture, sources its timber from Perhutani and not from the Jepara region, which allows for a more rigorous tracking system to help ensure that the timber used in the process is both legal and sustainable. This mill or furniture producer is also working with the GFTN to further develop its chain of custody systems, with the ultimate aim of reinstating FSC certification in at least 10 (5 with TFT and 5 with WWF) of the Perhutani districts.

Thus, while land transformation is of a high level of concern, Carrefour and its suppliers are working together to ensure that this impact is minimal.

Teak production is approximately 100-120 m^3 per hectare from 5-8 ha blocks. Replanting happens as soon as the timber is felled with intercropping predominantly by local communities. However, plantations are getting younger with 80-year cycles being reduced to 40 year.

1.2.2 Social Issues

Social issues are significant in Indonesia, and while Perhutani makes attempts at addressing them in some districts, they remain the most difficult to manage. Social issues include land tenure, access and resulting conflict, share of economic returns, use of land for agriculture and illegal logging. While communities are allowed to intercrop in the first couple of years of the new plantings, this is only a short-term solution to land use and access issues that may prevail.

Despite this, Perhutani is implementing a PMDH programme, provides significant employment[1], and the longevity of the plantations limit the potential for conflict over land ownership and access. Working with communities to ensure minimal social negative impact is a key component of any good forest management and of any forest certification scheme, such as FSC. By working with a traceable supply chain and in conjunction with WWF, Carrefour can influence the potential social risks and work towards mitigating any that arise.

1.2.3 *Biodiversity*

Anti-plantation campaigns have been targeted towards teak plantations, on the premise that plantations (especially single-species plantations or forest monocultures) tend to have lower levels of biodiversity than natural forests and may also be more susceptible to catastrophic damage, especially from pests and diseases but also from wind, storms and fires. In some countries, mixed plantations are being established to provide better soil cover and stability to increase biodiversity and to reduce commercial risks (source FAO – Pandey and Brown). As the affected area is large and different district operators use different practices, not all plantations will be well managed, which results in an overall high risk of negative impact.

Although in general biodiversity is a significant issue for teak plantations, in Java it is less so. Teak plantations managed by Perhutani have been in existence for more that 100 years, thus are not created from conversion from natural forest or other land specifically for plantation use. Through good forest management, the teak plantations incorporate buffer zones around water courses and the protection of High Conservation Value Forest (HCVF).

1.2.4 *Soil Erosion*

Soil erosion is a significant issue due to the nature of teak – requiring light and thus widely spaced trees; with large leaf water droplets and exposed land after clear felling and through the need for cleared undergrowth to encourage growth of the teak tree. However with good forest management, the inclusion of buffer zones around water courses, intercropping in the year immediately post felling, no new roads constructed and extraction of timber by hand or using cows, this potentially significant impact is reduced.

[1] It is estimated that the teak industry in Indonesia generates an estimated half a million jobs.

1.2.5 *Human Health*

Production is very labour intensive with the aim to employ local communities as much as possible. Felling uses a mixture of two-man ban saws and chainsaws. Protective clothing is minimal with workers wearing hard hats but no ear or eye protection, due to climate constraints. There are no serious hazards evident but due to the large number of people involved and there is a potential health and safety risk. Again the extent of this risk is determined by the quality of the management practices employed.

1.2.6 *Economic issues*

In Indonesia teak is produced in plantations, agro-forestry sites and a small proportion from natural forest. The main furniture production area is Jepara which consists of thousands of small workshops where furniture are hand made or semi-hand made; on the one hand this provides a lot of jobs and all the waste wood and small logs from farmers are used or re-used making it very efficient, but on the other hand illegally produced logs can easily be incorporated into the supply chain. Due to the low cost production process and potential for illegally sourced (sold at a cheaper price to legal timber) to be intermixed in the product, the final products are significantly cheaper and often of a lower quality, than that produced by machine in a furniture factory.

Carrefour sources its chairs directly from a larger processor, where the stages of production are integrated and there is greater guarantee of higher quality products. However, this comes at a cost, with chairs from a factory costing around 30% more.

The European market demands low prices for teak garden furniture (good quality timber) and the depressed market price encourages producers to source illegal timber. In 2003, a chair could be bought for less than 30-35 US$ and as low as 10 US$ in Jepara. To survive in a competitive market the buyer and ultimately the consumer needs to weigh up the price with quality and concerns over legality and sustainability.

1.3 *Justification of Qualitative Scores for Brass Fastening Production*

Mineral extraction and processing is considered a major area of concern to world's environment and human health. As we have no data on the source of the brass fastenings we have assumed medium scale operations and a medium level of management.

1.4 *Justification of Qualitative Scores for Glue Production*

Chemicals industry is considered to be a major area of concern with regard to most environmental issues, however glue production on its own is not considered a major issue in the world. As we have no data on the source of the glue we have assumed medium scale operations and a medium level of management.

1.5 *Justification of Qualitative Scores for Oil/Lubricant Production*

The petrochemical industry is considered to be a major area of concern with regard to most environmental issues. As we have no data on the source of the glue we have assumed medium scale operations and a medium level of management.

1.6 *Justification of Qualitative Scores for Sand Paper Production*

Paper and packaging production operations are a major area of concern with regard to the environment throughout the world. As we have no data on the source of the sand paper we have assumed medium scale operations and a medium level of management.

1.7 *Justification of Qualitative Scores for Packaging Material production*

Paper and packaging production operations are a major area of concern with regard to the environment throughout the world. As we have no data on the source of the sand paper we have assumed medium scale operations and a medium level of management.

1.8 *Justification of Qualitative Scores for Teak Component Manufacture*

There is great variety in the H+S standards in processing facilities in Indonesia. Health issues include – dust inhalation, eye infections, breathing problems etc resulting from lack of ventilation, dust extractors, lack of light, age and quality of machinery. The potential negative risk is therefore significant. However, again through working directly with its supplier, Carrefour is

trying to improve the health and safety standards in the processing factories. This would not be feasible if Carrefour sourced its timber from unknown sources.

For the other environmental issues, based on information provided by Carrefour, we have assumed low level of concern and a high level of management and control.

1.9 *JUSTIFICATION OF QUALITATIVE SCORES FOR CHAIR ASSEMBLY*

Chair assembly is less mechanically intensive than component manufacture, though similar operations take place. When compared with teak component manufacture we believe the level of concern and scale of operations to be lower for chair assembly.

For the other environmental issues, based on information provided by Carrefour, we have assumed low level of concern and a low level of risk.

1.10 *JUSTIFICATION OF QUALITATIVE SCORES FOR DISTRIBUTION*

The transport sector is considered to be a major area of concern with regard to most environmental issues. As we have limited data on the distribution processes we have assumed medium scale operations and a medium level of management.

1.11 *JUSTIFICATION OF QUALITATIVE SCORES FOR CHAIR USE*

For these environmental issues we believe there to be no concern and no risk in the use of the chair.

1.12 *JUSTIFICATION OF QUALITATIVE SCORES FOR CHAIR END OF LIFE*

Municipal solid waste and the operations associated with its management are a major area of concern in the EU, however it is well managed and highly regulated.

Annex D

Life Cycle Impact Assessment Methodology

1 LIFE CYCLE IMPACT ASSESSMENT

Life Cycle Impact Assessment (LCIA) involves three main steps:

Classification - all substances are sorted into classes according to the effect they have on the environment. For example, substances that contribute to the greenhouse effect or that contribute to ozone layer depletion are divided into two classes. Certain substances are included in more than one class. For example, NOx emissions are toxic, acidifying and contribute to eutrophication.

Characterisation - the substances are aggregated within each class to produce an effect score. Weighting factors are applied to account for the fact that some substances may have a more intense effect than others.

Normalisation - each effect score is benchmarked against the known total effect for this class, in order to gain a better understanding of the relative size of an effect. For example, the Eco-indicator method normalizes with effects caused by the average European during a year.

Evaluation or weighting - the normalized effect scores are multiplied by a weighting factor representing the relative importance of the effect.

The following, established LCIA methods were used to calculate environmental effect scores for each activity and category of impact. An outline of each method, extracted from the ECOINVENT report, *Implementation of Life Cycle Impact Assessment Methods* (1), is provided below.

1.1 CUMULATIVE ENERGY DEMAND

Cumulative Energy Requirements Analysis (CERA) aims to investigate the energy use throughout the life cycle of a good or a service. This includes the direct uses as well as the indirect or grey consumption of energy due to the use of, for example construction materials or raw materials. This method has been developed in the early seventies after the first oil price crisis and

(1) Frischknecht *et al* (2003). *Implementation of Life Cycle Assessment Methods*. ECOINVENT Report No. 3. Swiss Centre for Life Cycle Inventories, Dubendorf, 2003.

has a long tradition. The cumulative energy demand (CED) is widely used as a screening indicator for environmental impacts. CED-results can also be used for plausibility checks because it is quite easy to judge on the basis of the CED whether or not major errors have been made.

Different ways of determining the primary energy requirement exist. For CED calculations one may chose the lower or the upper heating value of primary energy carriers, where the latter includes the evaporation energy of the water present in the flue gas. Furthermore one may distinguish between energy requirements of renewable and non-renewable resources. Finally, different ways exist how to handle nuclear and hydro electricity. So far there is no standardized method of assessment. All as a result, the CED-indicator is split into five categories (non-renewable energy resources, fossil; non-renewable energy resources, nuclear; renewable energy resources, biomass; renewable energy resources, wind, solar, geothermal; renewable energy resources, water). For the purpose of this assessment these are combined into two categories: non-renewable energy resources; and renewable energy resources.

Common to all categories is the theory that all energy carriers have an intrinsic value. This intrinsic value is determined by the amount of energy withdrawn from nature. Impact factors to calculate this quantity have been developed for the ECOINVENT database and are shown in the diagram in *Figure 1.1*.

Figure 1.1 Impact Factors for Cumulative Energy Demand

Name	Category	SubCategory	Unit	cumulative energy demand	cumulative energy demand	cumulative energy demand	cumulative energy demand	cumulative energy demand
SubCategory				fossil	nuclear	biomass	wind, solar, geothermal	water
Name				non-renewable energy resources, fossil	non-renewable energy resources, nuclear	renewable energy resources, biomass	renewable energy resources, wind, solar, geothermal	renewable energy resources, water
Location				GLO	GLO	GLO	GLO	GLO
Unit				MJ-Eq	MJ-Eq	MJ-Eq	MJ-Eq	MJ-Eq
Coal, brown, in ground	resource	in ground	kg	9.90				
Coal, hard, unspecified, in ground	resource	in ground	kg	19.10				
Energy, geothermal	resource	in ground	MJ				1.00	
Energy, gross calorific value, in biomass	resource	biotic	MJ			1.00		
Energy, kinetic, flow, in wind	resource	in air	MJ				1.00	
Energy, potential, stock, in barrage water	resource	in water	MJ					1.00
Energy, solar	resource	in air	MJ				1.00	
Gas, mine, off-gas, process, coal mining	resource	in ground	Nm3	39.80				
Gas, natural, in ground	resource	in ground	Nm3	40.30				
Uranium, in ground	resource	in ground	kg		560'000.00			
Oil, crude, in ground	resource	in ground	kg	45.80				
Wood, hard, standing	resource	biotic	m3			0		
Wood, soft, standing	resource	biotic	m3			0		
Wood, unspecified, standing	resource	biotic	m3			0		
Peat, in ground	resource	biotic	kg	9.90				

1.1.1 *Quality considerations*

Most of the uncertainties associated with this impact assessment method arise from the choice impact factor for different energy resources. For example, for uranium it is quite disputable which value to chose and so CED-values reported for "non renewable energy resources/nuclear" are less reliable than those for "non renewable energy resources/fossil".

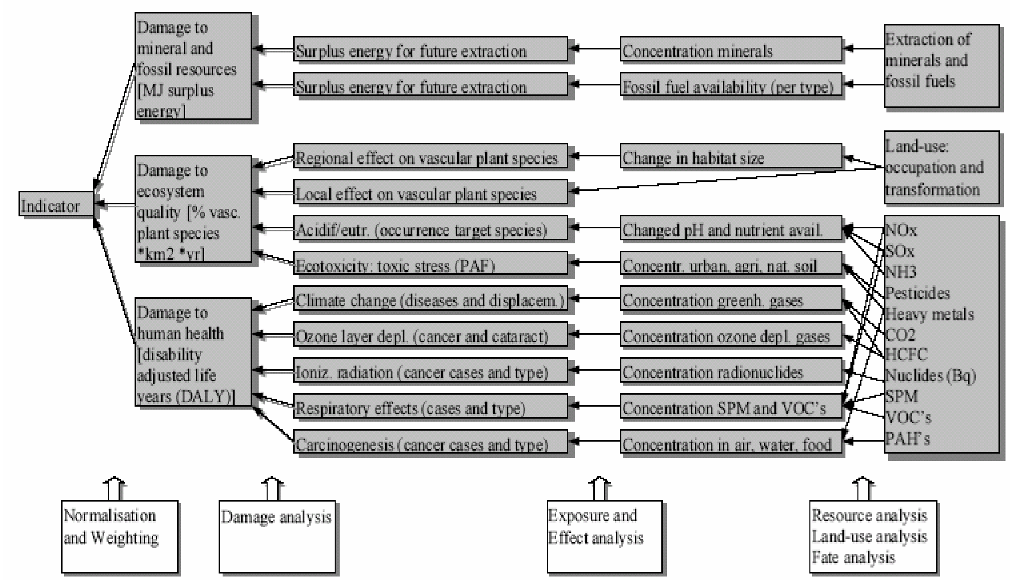
In general, the method of cumulative energy demand is useful to get a general view of the energy-related environmental impacts in a life cycle and for a first comparison of individual products. However, energy use does not give a full picture for all environmental impacts in the life cycle of goods and services. Furthermore, environmental impacts vary among different energy resources. For example, the impacts of coal use in relation to energy content are normally more severe than those due to using natural gas. Thus, cumulative energy demand cannot be the one and only method for evaluating the environmental impacts of a good or service.

1.2 *ECO-IDICATOR 99* (1)

In 1997 a group of scientists introduced a new method for life cycle impact assessment – the Eco-indicator 99. The practical aim of this method is to determine a single score (measured in ecopoints) for the environmental impact of a product, or process. A diagrammatic representation of the methodology required to calculate such scores is shown in *Figure 1.2* and a full description of the method can be obtained from http://www.pre.nl/download/EI99_methodology_v3.pdf.

(1) Goedkoop, M. *et al* (2001). *The Eco-Indicator 99. A damaged oriented method for life cycle impact assessment. Methodology Report.* Pre Consultants, Amersfoort.

Figure 1.2 *Eco-indicator 99 Methodological Approach*



During this assessment, the eco-indicator 99 method was used to calculate ecopoint scores for activities contributing to the impact categories *Acidification & Eutrophication* and *Ecotoxicity*. In order to use this method to assess inventory data from the ECOINVENT database (as used in this assessment), it is necessary to link the elementary flows of ECOINVENT data to the substance names given in the Eco-indicator 99 report. The background paper, *Implementation of Life Cycle Impact Assessment Methods* (1) describes this process, outlining difficulties in assignment and some assumptions that had to be made.

1.2.1 *Quality Considerations*

For many of the substances included in the ECOINVENT database, the Eco-indicator 99 reports do not provide damage factors. In fact, for only 38% of the substances in the ECOINVENT data damage factors are available. For example, the eco-indicator 99 report gives no damage factors for emissions of nutrients and acids into water, nor soil. This presents limitations of the quality of results. At the time of assessment this was considered the most appropriate and up-to-date assessment method available.

(1) Frischknecht *et al* (2003). *Implementation of Life Cycle Assessment Methods*. ECOINVENT Report No. 3. Swiss Centre for Life Cycle Inventories, Dubendorf, 2003.

However, it is considered that it is recognised that it may be more reliable use an alternative method to assess the impact categories acidification and eutrophication.

1.3 *IPPC 2001 (CLIMATE CHANGE)*

The characterisation of different gaseous emissions according to their global warming potential and the aggregation of different emissions in the impact category C*limate Change* is one of the most widely used methods in LCIA. The method evaluates the emissions of greenhouse gases due to anthropogenic activities and calculates them as global warming potentials (GWPs). GWPs are an index for estimating relative global warming contribution due to atmospheric emission of a kg of a particular greenhouse gas compared to the emission of a kg of carbon dioxide.

Direct emissions of greenhouse gasses.

Impact/characterisation factors are taken from the Intergovernmental Panel on Climate Change [(1)].

Indirect effects of hydrocarbons.

Values for indirect effects of hydrocarbons are not considered in this method. Available ranges are quite large and it is not possible to determine one relevant figure.

Lower stratosphere + upper troposphere emissions.

There are several specific effects of emissions in high altitude, which lead to a comparably higher contribution of aviation to the problem of climate change.
The available information has been used to estimate global warming potentials for these emissions roughly. However, it has to be noted that these figures have an uncertainty.

(1) see ECOINVENT report for full listing

Nitrous oxide and particulate emissions

Experts are continuing further discussion on the contribution of emissions of nitrous oxide from emissions near the ground, such as from vehicles. The effect is not the same as for emissions from aviation, but it might be as important. A GWP of the order of 5 has been cited by the IPCC and is used in this assessment.

Particulate emissions and their contribution to climate change are also debated in the scientific community. These effects are not taken into account in this method because official factors are not available.

1.3.2 *Quality considerations*

The quality of implementation of this impact assessment method in the ECOINVENT database is good, as published characterisation factors were used. The uncertainty of the characterisation factors itself cannot be addressed here.

It must be noted, however that this characterisation of the global warming potential addresses only a part of the problem climate change. Many important aspects, such as indirect and induced effects are not included in the assessment.

Annex E

Data Sources, Assumptions and Substitutions

1 *INTRODUCTION*

This Annex contains details and metadata regarding the source, scope, age and quality of all life cycle inventory (LCI) data used, together with details of all assumptions and substitute datasets that were used during the assessment of environmental impacts.

Please note that a significant limitation of the assessment is that the majority of data collected relate to European conditions (material production, transport, waste treatment etc.). There are very little data available that relate to these processes as carried out in Indonesia.

2 TEAK PRODUCTION

2.1 ASSUMPTIONS

2.1.1 Fuel Consumption

Food and Agriculture Organisation (FAO) practice (1) states that teak plantation management typically involves 3 thinnings (at 4-5, 10-15 and 15-20 years) prior to final felling. Data for managed Scots Pine plantations (2) consider fuel consumption to be in the region of 1 litre petrol (chainsaws) and one litre diesel (forwarder use) for each thinning and 0.6 litres petrol and 0.7 litres diesel for final felling - giving a total of 3.6 litres petrol and 3.7 litres diesel consumed during forestry practices. Fuel consumption for the production of 1m3 of Azobe in West Africa using highly mechanised practices was calculated to be 13 litres (3). Richard Murphy (personal communication) advised that plantation logging in Indonesia is likely to be of fuel consumption intensity lower than this, but higher than the average European figures for fuel consumption of 1-2 litres per m3 timber harvested. As such a figure of 7.3 litres was assumed to be a reasonable assumption with regard to fuel consumption.

2.1.2 Biogenic Carbon Dioxide

On average, wood binds 1.87 kg CO_2/kg growth (4). This uptake of carbon dioxide has not been taken into account during modelling, however, as it was assumed that uptake would be balanced by carbon dioxide releases at end of life (and during treatment of wood wastes throughout the life cycle, such as burning of saw dust during teak component production). These biogenic emissions of carbon dioxide will similarly be discounted from the assessment.

2.1.3 Emissions

A study of low intensity harvesting of Meranti in Malaysia detailed a felling technique using Stihl chainsaws and tractors to haul trees to log yards (prior to dispatch to sawmills by lorries) (5). Similar practices are assumed in Indonesia and CIFOR (personal

(1) Brown, C. and Pandey, D (2004). Teak: A Global Overview – http://www.fao.org/DOCREP/X4565E/x4565e03.htm 07/10/04
(2) Marta Lopez-Usero (2000). Sustainable forest management and forest certification: LCA used as a tool to evaluate the eco-profile of Latvian timber
(3) VROM (2002) – LCA for acetylated wood. Final report 2: light duty piling in fresh water use. Conducted by the Imperial College London and SHR Timber Research for the Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (VROM).
(4) Scharai-Rad and Welling (2002). Environmental and energy balances of wood products and substitutes. FAO.
(5) Sayer et al 1995: cited in Rugge B A (1999). Life Cycle Assessment of the Tropical Timber Meranti (Shorea). MSc Project, University of London Centre for Environmental Technology

communication) advises that harvesting practices in Indonesian plantation are predominantly manual. Emissions from machinery use were obtained for a Stihl chainsaw and agricultural tractor (1).

2.1.4 *Conversion Factors*

Table 2.1 *Conversion Factors*

Parameter	Quantity	Unit	Source
Average gross calorific value of hardwood	12700	MJ/m^3	Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG
Average density of teak	675	kg/m^3	http://www.engineeringtoolbox.com/wood-density-24_40.html
Density petrol	0.734	kg/l	DTI - http://www.dti.gov.uk/energy/inform/energy_prices/annex_b_mar04.shtml
Density diesel	0.86	kg/l	DTI - http://www.dti.gov.uk/energy/inform/energy_prices/annex_b_mar04.shtml

2.2 DATA GAPS

No data were available for nursery, seedling planting and site preparation (scarification) activities. In Indonesia the local community manages land between rotation periods (low intensity agriculture) and so it is assumed that limited site preparation is required. Seedling planting is also assumed to be manual. There will be some impacts associated with the transport of seedlings from nursery to the plantation site. However, these are likely to be small in comparison with the transport of logs to sawmill at final felling. It is unknown as to whether fertilisers or pesticides are used during seedling production or plant raising. Only two other studies, both of managed plantations in Europe, report such chemical use.

2.3 INVENTORY

Table 2.2 *Inventory 1m3 Teak Log Production*

Flow	Quantity	Unit	Input/Output	LCI Process Data Used
Petrol	2.6424	kg	I	ECOINVENT v1.01, petrol, low-sulphur, at refinery

(1) Fedrau, 2000: cited in Karjalainen, T. et al (2001). Energy, carbon and other material flows in the life cycle assessment of forestry and forest products. European Forest Institute discussion paper 10.

Flow	Quantity	Unit	Input/Output	LCI Process Data Used
Diesel	3.182	kg	I	ECOINVENT v1.01, diesel, at refinery
Biomass, renewable energy	12700	MJ	I	n/a – elementary flow
CO2	19.31737	kg	O	n/a – elementary flow
N20	0.007053248	kg	O	n/a – elementary flow
CH4	0.034900844	kg	O	n/a – elementary flow

2.4 *METADATA*

2.4.1 *Petrol*

Table 2.3 ECOINVENT Metadata, Petrol

Name	Petrol, low-sulphur, at refinery
Location	Europe
Unit	kg
Included Processes/ Description	Energy use for production, no process specific emissions and material use. Estimation for the conversion of refinery production to low-sulphur petrol with a sulphur content < 50ppm (Today 150ppm). A additional energy use of 6% has been estimated. Data for additional emissions and additional infrastructure were not available.
Date	2005
Geography	Estimation for the European situation.
Technology	Different technologies might be used to reduce the sulphur content, e.g. better catalysts, new hydrodesulphurisation process, higher storage capacities, separate transport systems.
Comment on representativeness	Literature data with calculations based on refinery models.
Source	Jungbluth N. (2003). Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, PSI

2.4.2 *Diesel*

Table 2.4 ECOINVENT Metadata, Diesel

Name	Diesel, at refinery
Location	Europe
Unit	kg

Name	Diesel, at refinery
Included Processes/ Description	All processes on the refinery site excluding the emissions from combustion facilities, including wastewater treatment, process emissions and direct discharges to rivers.
Date	2000
Geography	Assumption for the European average.
Technology	Assumption for average technology.
Comment on representativeness	Many data were available only for 1 to 5 plants and have been extrapolated to the European situation.
Source	Jungbluth N. (2003). Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, PSI

3 BRASS/FASTENING PRODUCTION

3.1 ASSUMPTIONS

3.1.1 Component Weight

Total weight of brass fastenings used in one chair: 0.1 kg (Nicolas Regouby and Eko Wahyu Hidayat, personal communication).

3.2 DATA GAPS

No data regarding the packaging and transport of fastenings following manufacture could be gathered. The impacts associated with these processes are assumed to be minimal in comparison the extraction and forming processes of the brass itself, however.

3.3 INVENTORY

Table 3.1 Inventory Data used for Brass Fastening Production

Flow	Quantity	Unit	LCI Process Data Used
Brass	0.1	kg	ECOINVENT v1.01, brass, at plant
Brass forming	0.1	kg	ECOINVENT v1.01, casting, brass

3.4 METADATA

3.4.1 Brass

Table 3.2 ECOINVENT Metadata, Brass

Name	Brass, at plant
Location	Switzerland

Name	Brass, at plant
Unit	kg
Included Processes/ Description	Copper and zinc including their melting and casting of brass ingots. Stands for brass with 70% Cu and 30% Zn. All data are calculated based on assumptions and theoretical models. Their overall quality is poor.
Date	2000
Geography	Production data relate to the European average. Transports of inputs relate to the consumption in Switzerland
Technology	Assumed energy mix for melting. Abatement of air emissions assumed
Comment on representativeness	based on literature and internet
Source	Blaser S., Classen M., Jungbluth N. (2003). Life Cycle Inventories of Metals. Final report No. 10 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, EMPA-DU

3.4.2 Brass Forming

Table 3.3 ECOINVENT Metadata, Brass Forming

Name	Casting, brass
Location	Switzerland
Unit	kg
Included Processes/ Description	melting of copper and zinc and casting of brass parts. Metal input is not included.. All data are calculated based on assumptions and theoretical models. Their overall quality is poor.
Date	2003
Geography	Data relate to the European average.
Technology	Assumed energy mix for melting. Abatement of air emissions assumed
Comment on representativeness	based on literature and internet
Source	Blaser S., Classen M., Jungbluth N. (2003). Life Cycle Inventories of Metals. Final report No. 10 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, EMPA-DU

4 GLUE PRODUCTION

4.1 ASSUMPTIONS

4.1.1 Weight

Approximate weight of polyurethane glue used in one chair: 0.029 kg (Nicolas Regouby and Eko Wahyu Hidayat, personal communication).

4.2 DATA GAPS

No data regarding the packaging and transport of glue following manufacture could be gathered. The impacts associated with these processes are assumed to be minimal in comparison the extraction and forming processes of the glue itself, however.

4.3 INVENTORY

Table 4.1 Inventory Data used for Polyurethane Glue Production

Flow	Quantity	Unit	LCI Process Data Used
Glue	0.029	kg	ECOINVENT v1.01, polyurethane, flexible foam, at plant

4.4 METADATA

4.4.1 Glue

Table 4.2 ECOINVENT Metadata, Polyurethane

Name	Polyurethane, flexible foam, at plant
Location	Europe
Unit	kg

Name	Polyurethane, flexible foam, at plant
Included Processes	This dataset includes the transport of the monomers as well as the production (energy, air emissions) of the PUR foam
Date	1997
Geography	typical composition for European conditions
Technology	Present technology used in Europe. Transport and infrastructure - average values added.
Comment on representativeness	Data from industry report
Source	Hischier R. (2003). Life Cycle Inventories of Packaging and Graphical Paper. Final report No. 11 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, EMPA-SG

5 OIL PRODUCTION

5.1 ASSUMPTIONS

5.1.1 *Weight*

Approximate weight of oil used in the production of one chair: 0.008 kg (Nicolas Regouby and Eko Wahyu Hidayat, personal communication).

5.2 DATA GAPS

No data regarding the packaging and transport of oil following manufacture could be gathered. The impacts associated with these processes are assumed to be minimal in comparison the extraction and forming processes of the oil itself, however.

5.3 INVENTORY

Table 5.1 Inventory Data used for Oil Production

Flow	Quantity	Unit	LCI Process Data Used
Oil	0.008	kg	ECOINVENT v1.01, lubricating oil, at plant

5.4 METADATA

5.4.1 *Oil*

Table 5.2 ECOINVENT Metadata, Oil

Name	**Lubricating oil, at plant**
Location	Europe
Unit	kg
Included Processes/ Description	Raw materials and chemicals used for production, transport of materials to manufacturing plant, estimated emissions to air and water from production (incomplete), estimation of energy demand and infrastructure of the plant (approximation). Solid wastes omitted. The functional unit represent 1 kg of liquid lubricating oil. Large uncertainty of the process data due to weak data on the production process and missing data on process emissions.
Date	2000
Geography	Data used has no specific geographical origin (stoichiometry). Average European processes for raw materials, transport requirements and electricity mix used.
Technology	Production out of diesel by hydrocracking, followed by distillation and dewaxing. The overall process yield is assumed to be 75%. Inventory bases on theoretical reflections. The emissions to air are rough estimates.
Comment on representativeness	Process data based on stoechiometric calculations of few literature sources. Energy demand based on approximation from large chemical plant. Process emissions based on estimations only.
Source	Althaus H.-J. (2003). Life Cycle Inventories of Chemicals. Final report No. 8 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-DU

6 SAND PAPER PRODUCTION

6.1 ASSUMPTIONS

6.1.1 Weight

Approximate weight of sand paper used in the manufacture of one chair: 0.01 kg (Nicolas Regouby and Eko Wahyu Hidayat, personal communication).

6.2 DATA GAPS

No data regarding the relative weights of sand, paper and adhesive comprising the sand paper could be found. It was considered that the paper would comprise the predominant weight and, as such, the impacts associated with its production would outweigh those associated with sand mining, adhesive production and sand paper production. The production of paper has therefore been taken as a proxy for the production of sand paper.

No data regarding the packaging and transport of sand paper following manufacture could be gathered. The impacts associated with these processes are assumed to be minimal in comparison the extraction and forming processes of the sand paper itself, however.

6.3 INVENTORY

Table 6.1 Inventory Data used for Sand Paper Production

Flow	Quantity	Unit	LCI Process Data Used
Sand paper	0.01	kg	ECOINVENT v1.01, kraft paper, unbleached, at plant

6.4 *METADATA*

6.4.1 *Paper*

Table 6.2 ECOINVENT Metadata, Paper

Name	**Kraft paper, unbleached, at plant**
Location	Europe
Unit	kg
Included Processes	This module includes the European production of unbleached kraft paper in an integrated mill – including transports to paper mill, wood handling, chemical pulping, paper production, energy production on-site and internal waste water treatment.
Date	2000
Geography	Data from one European producer and from a Finnish database used as European average data.
Technology	Present technology used in Europe. Transport and infrastructure - average values added.
Source	Hischier R. (2003). Life Cycle Inventories of Packaging and Graphical Paper. Final report No. 11 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, EMPA-SG

7 *CARDBOARD PACKAGING PRODUCTION*

7.1 *ASSUMPTIONS*

7.1.1 *Weight*

Approximate weight of cardboard packaging used for one chair: 0.325 kg (Nicolas Regouby and Eko Wahyu Hidayat, personal communication).

7.2 *DATA GAPS*

No data regarding the further packaging and transport of cardboard following manufacture could be gathered. The impacts associated with these processes are assumed to be minimal in comparison the extraction and forming processes of the glue itself, however.

7.3 *INVENTORY*

Table 7.1 Inventory Data used for Cardboard Packaging Production

Flow	Quantity	Unit	LCI Process Data Used
Cardboard	0.325	kg	ECOINVENT v1.01, packaging, corrugated board, mixed fibre, single wall, at plant

7.4 METADATA

7.4.1 Cardboard Packaging

Table 7.2 ECOINVENT Metadata, Cardboard Packaging

Name	**Packaging, corrugated board, mixed fibre, single wall, at plant**
Location	Europe
Unit	kg
Included Processes	This module includes the production of boxes out of corrugated board. It contains the steps of cutting, folding and printing. The inputs of corrugated board, inks and glues are considered, as well as the electricity consumption.
Date	1999
Geography	Estimation based on average data from European producers, collected from FEFCO
Technology	Average of present used technology
Source	Hischier R. (2003). Life Cycle Inventories of Packaging and Graphical Paper. Final report No. 11 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, EMPA-SG

8 TEAK COMPONENT MANUFACTURE

8.1 ASSUMPTIONS

8.1.1 Inventory Data

All inputs to and outputs from the production process, with the exception of air emissions, were provided by Nicolas Regouby and Eko Wahyu Hidayat at Carrefour. The weight of sand paper used at factory was estimated.

8.1.2 Electricity Generation

Life Cycle Inventory (LCI) data were taken from the ECOINVENT database in order to model the impacts associated with electricity generation. The process 'electricity, medium voltage, aluminium industry, at grid' was chosen, as this was the only dataset available that referred to generation outside Europe.

8.2 DATA GAPS

No data were available for the emissions associated with the combustion of sawdust in the kiln for log drying. This was not thought to represent a significant emission. For example, one study looking at data from a US sawmill stated that emissions from the site were minor (1).

8.3 INVENTORY

Table 8.1 Inventory for Teak Components used in the Manufacture of One Chair

Flow	Quantity	Unit	Input/Output	LCI Process data used
Logs	12.2	kg	I	See Section E2

(1) Milota, M.R. (2004).. Phase 1 Final Report (Review Draft). Module B: Softwood Lumber – Pacific Northwest Region.

Flow	Quantity	Unit	Input/Output	LCI Process data used
Sand Paper	0.05	kg	I	See Section E6
Oil	0.01	kg	I	See Section E5
Glue	0.03	kg	I	See Section E4
Electricity	1.8	kWh	I	ECOINVENT v1.01, electricity, medium voltage, aluminium industry, at grid
Water	6	litres	I	n/a – elementary flow
Sand paper	0.12	kg	O - re-used	n/a
Oil	0.004	kg	O - re-used	n/a
Tyres	0.0001	kg	O - stockpiled	n/a
Saw dust	4.866	kg	O - combusted on site for log drying	Data missing
Dowel	1.22	kg	O - used for construction on site	n/a
Wood components	6.083	kg	O	n/a

8.4 METADATA

8.4.1 Electricity

Table 8.2 ECOINVENT Metadata, Electricity Generation

Name	Electricity, medium voltage, aluminium industry, at grid
Location	Global
Unit	kWh
Included Processes/ Description	This dataset describes the transformation high to medium voltage, the transmission of electricity at medium voltage. Included are electricity losses and direct SF6-emissions to air.
Date	2000
Geography	The calculation of total specific losses is based on national data. Specific infrastructure demand is based on Swiss data. Specific SF6-Emissions (percentage of SF6 stock) are mainly based on German data.
Technology	Average technology used to transmit and distribute electricity. Includes underground and overhead lines, as well as air-, vacuum- and SF6-insulated high-to-medium voltage switching stations.
Comment on representativeness	Attribution of total losses to losses on medium voltage level is based on assumptions.
Source	Frischknecht, R. and Faist Emmenegger, M. (2003). Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, PSI

9 CHAIR ASSEMBLY

9.1 ASSUMPTIONS

9.1.1 Chair Weight

Average weight of one chair: 5.9 kg (Nicolas Regouby and Eko Wahyu Hidayat, personal communication).

9.1.2 Inventory Data

All inputs to and outputs from the production process, with the exception of waste wood generation, were provided by Nicolas Regouby and Eko Wahyu Hidayat at Carrefour. The weight of sand paper used at factory was estimated.

9.1.3 Electricity Consumption and Generation

The quantity of electricity required to produce one chair was calculated on the basis of:

- a monthly factory electricity consumption of 58 000 kWh, with 30% of this allocated to the production of Carrefour's chairs (Nicolas Regouby and Eko Wahyu Hidayat, personal communication); and
- a monthly production of 13 200 chairs (based on an average 550 chairs produced per day, as stated by Nicolas Regouby and Eko Wahyu Hidayat, and an assumed 24-day working month).

Life Cycle Inventory (LCI) data were taken from the ECOINVENT database in order to model the impacts associated with electricity generation. The process 'electricity, medium voltage, aluminium industry, at grid' was chosen, as this was the only dataset available that referred to generation outside Europe.

9.1.4 Wood Waste Generation and Treatment

Figures for waste wood generation have been substituted from an LCA of a beech chair of similar weight, manufactured in Italy [(1)]. These were the only available data for the manufacture of wood furniture and corresponded to a relatively simple

(1) Nicoletti G M, Notarnicola B and Tassielli G. LCA of beech manufactured products. Source: Richard Murphy, Imperial College, London.

manufacturing process involving the following processes: squaring, unframing, smoothing, tenonising, mortising, assembly, painting and packaging.

It was assumed that wood wastes generated on site would be disposed of at landfill. ECOINVENT data for landfilling European wood waste were used as a proxy as no data were available for Indonesian landfill. The impacts associated with this waste treatment are small and so are not thought to have influence on results.

9.2 *DATA GAPS*

No data were available for the quantity of water, if any, consumed during the production process.

9.3 *INVENTORY*

Table 9.1 Inventory for the Production of One Chair

Flow	Quantity	Unit	Input/Output	LCI Process data used
Wood components	6.083	kg	I	See Section E8
Brass fastenings	0.1	kg	I	See Section E2
Cardboard Packaging	0.33	kg	I	See Section E7
Glue	0.001	kg	I	See Section E4
Sand paper	0.05	kg	I	See Section E6
Electricity	1.3	kWh	I	ECOINVENT v1.01, electricity, medium voltage, aluminium industry, at grid
Wood manufacturing waste to landfill	0.226	kg	O	ECOINVENT v1.01, disposal, wood untreated, 20% water, to sanitary landfill
Faulty wooden components	0.058	kg	O	ECOINVENT v1.01, disposal, wood untreated, 20% water, to sanitary landfill
Packaged teak chair	6.225	kg	O	n/a

9.4 METADATA

9.4.1 Electricity

Table 9.2 ECOINVENT Metadata, Electricity Generation

Name	Electricity, medium voltage, aluminium industry, at grid
Location	Global
Unit	kWh
Included Processes/ Description	This dataset describes the transformation high to medium voltage, the transmission of electricity at medium voltage. Included are electricity losses and direct SF6-emissions to air.
Date	2000
Geography	The calculation of total specific losses are based on national data. Specific infrastructure demand is based on Swiss data. Specific SF6-Emissions (percentage of SF6 stock) are mainly based on German data.
Technology	Average technology used to transmit and distribute electricity. Includes underground and overhead lines, as well as air-, vacuum- and SF6-insulated high-to-medium voltage switching stations.
Comment on representativeness	Attribution of total losses to losses on medium voltage level are based on assumptions.
Source	Frischknecht, R. and Faist Emmenegger, M. (2003). Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, PSI

9.4.2 Wood Waste Disposal

Table 9.3 ECOINVENT Metadata, Wood Waste Disposal

Name	Disposal, wood untreated, 20% water, to sanitary landfill
Location	Switzerland
Unit	kg
Included Processes/ Description	Waste-specific short-term emissions to air via landfill gas incineration and landfill leachate. Burdens from treatment of short-term leachate (0-100a) in wastewater treatment plant (including WWTP sludge disposal in municipal incinerator). Long-term emissions from landfill to groundwater (after base lining failure). Inventoried waste contains 100% natural wood; waste composition (wet, in ppm): upper heating value 15.36 MJ/kg; lower heating value 13.99 MJ/kg; H2O 174080; O 372180; H 50163; C 401470; S 125.51; N 986.98; P 108.97; B 2.1107; Cl 330.95; F 21.106; As 0.42213; Cd 0.20051; Co 0.086772; Cr 0.65782; Cu 4.1482; Hg 0.31976; Mn 53.118; Mo 0.8302; Ni 0.55581; Pb 27.868; Zn 17.807; Fe 15.479; Ca 130.89; Al 6.3322; K 65.412; Mg 197.56; Na 14.071; Share of carbon in waste that is biogenic 100%. Overall degradability of waste during 100 years: 1.5%.

Name	Disposal, wood untreated, 20% water, to sanitary landfill
Date	2000
Geography	Technology encountered in Switzerland in 2000. Landfill includes base seal, leachate collection system, and treatment of leachate in municipal wastewater treatment plant.
Technology	Swiss municipal sanitary landfill for biogenic or untreated municipal waste ('reactive organic landfill'). Landfill gas and leachate collection system. Recultivation and monitoring for 150 years after closure.
Comment on representativeness	Landfill model based on observed leachate concentrations in literature. Extrapolated to 60'000 years heeding chemical characteristics. Initial waste composition from various literature sources.
Source	Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG

10 DISTRIBUTION

10.1 ASSUMPTIONS

The transport assumptions used to model distribution steps in the life cycle are detailed in *Table 10.1*.

The type of vehicle used to transport between each step was selected on the basis on the quantity of wood/chairs transported (information provided by Nicolas Regouby and Eko Wahyu Hidayat) and the payload of the vehicle. All transport distances were converted into tonne-kilometres in order to take into account the relative quantity of materials being transported. It was assumed that all heavy goods vehicles operate 50% loaded (full out and empty on return) and container ships operate 100% loaded.

Table 10.1 Transport Assumptions

Transport step	Vehicle used (ECOINVENT data)	Distance travelled (km, one-way)
Logs from plantation to sawmill	40t truck	625 km (Carrefour - average)
Chair from factory to warehouse (Indonesia)	<3.5t van	68 km (Carrefour)
Chair from warehouse (Indonesia) to depot (Le Havre)	Container ship	12000 km (approx distance between Jakarta and Le Havre)
Chair from depot (Le Havre) to intermediate warehouses	16t truck	520 km (approximate - calculated with distance calculator)
Chair from intermediate warehouses to retail outlet	16t truck	250 km (assumed average)
Chair from retail outlet to consumer	Passenger car	50 km (assumed average)

10.2 METADATA

10.2.1 40 Tonne Truck

Table 10.2 ECOINVENT Metadata, 40 Tonne Truck

Name	Transport, lorry 40t
Location	Switzerland

Name	Transport, lorry 40t
Unit	tkm
Included Processes/ Description	Operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road. Inventory refers to the entire transport life cycle. For road infrastructure, expenditures and environmental interventions due to construction, renewal and disposal of roads have been allocated based on the Gross tonne kilometre performance. Expenditures due to operation of the road infrastructure, as well as land use have been allocated based on the yearly vehicle kilometre performance. For the attribution of vehicle share to the transport performance a vehicle lifetime performance of 5.23E06 tkm/vehicle have been assumed.
Date	2000
Geography	The data for vehicle operation and road infrastructure reflect Swiss conditions. Data for vehicle manufacturing and maintenance represents generic European data. Data for the vehicle disposal reflect Swiss situation.
Technology	For vehicle operation all technologies are included in the average data. Road construction comprises bitumen and concrete roads. For the manufacturing of vehicles, the data reflects current modern technologies
Source	Spielmann M. (2003). Life Cycle Inventories of Transport Services. Final report No. 14 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

10.2.2 16 Tonne Truck

Table 10.3 ECOINVENT Metadata, 16 Tonne Truck

Name	Transport, lorry 16t
Location	Europe
Unit	tkm
Included Processes/ Description	Operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road. Inventory refers to the entire transport life cycle. For road infrastructure, expenditures and environmental interventions due to construction, renewal and disposal of roads have been allocated based on the Gross tonne kilometre performance. Expenditures due to operation of the road infrastructure, as well as land use have been allocated based on the yearly vehicle kilometre performance. For the attribution of vehicle share to the transport performance a vehicle lifetime performance of 1.58E06 tkm/vehicle have been assumed.
Date	2000
Geography	Data refers to average transport conditions in Europe (EU 15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the UK).The data for road infrastructure reflect Swiss conditions. Data for vehicle manufacturing and maintenance represents generic European data. Data for the vehicle disposal reflect Swiss situation.
Technology	For vehicle operation all technologies are included in the average data. Road construction comprises bitumen and concrete roads. For the manufacturing of vehicles, the data reflects current modern technologies

Name	Transport, lorry 16t
Source	Spielmann M. (2003). Life Cycle Inventories of Transport Services. Final report No. 14 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

10.2.3 <3.5 Tonne Van

Table 10.4 ECOINVENT Metadata, <3.5 Tonne Van

Name	Transport, van, <3.5t
Location	Europe
Unit	tkm
Included Processes/ Description	Operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road. Inventory refers to the entire transport life cycle. For road infrastructure, expenditures and environmental interventions due to construction, renewal and disposal of roads have been allocated based on the Gross tonne kilometre performance. Expenditures due to operation of the road infrastructure, as well as land use have been allocated based on the yearly vehicle kilometre performance. For the attribution of vehicle share to the transport performance a vehicle lifetime performance of 7.05E04 tkm/vehicle have been assumed.
Date	2000
Geography	Data refers to average transport conditions in Europe (EU 15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the UK).The data for road infrastructure reflect Swiss conditions. Data for vehicle manufacturing and maintenance represents generic European data. Data for the vehicle disposal reflect Swiss situation.
Technology	For vehicle operation all technologies are included in the average data. Road construction comprises bitumen and concrete roads. For the manufacturing of vehicles, the data reflects current modern technologies
Source	Spielmann M. (2003). Life Cycle Inventories of Transport Services. Final report No. 14 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

10.2.4 Container Ship

Table 10.5 ECOINVENT Metadata, Container Ship

Name	Transport, transoceanic freight ship
Location	Europe
Unit	tkm

Name	Transport, transoceanic freight ship
Included Processes/ Description	The module calls the modules addressing: operation of vessel; production of vessel; construction and land use of port; operation, maintenance and disposal of port. Inventory refers to the entire transport life cycle. Port infrastructure expenditures and environmental interventions are allocated based the yearly throughput (0.37). Vessel manufacturing is allocated based on the total kilometric performance (2'000'000km) and its transport performance (50000/unit). For each transport activity 2 ports are required.
Date	2000
Geography	Data from one port in Netherlands is employed as an estimate for international water transportation.
Technology	HFE based steam turbine and diesel engines.
Source	Spielmann M. (2003). Life Cycle Inventories of Transport Services. Final report No. 14 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

10.2.5 Passenger Car

Table 10.6 ECOINVENT Metadata, Passenger Car

Name	Operation, passenger car
Location	Europe
Unit	km
Included Processes/ Description	The inventory includes diesel and petrol supply. Direct airborne emissions of gaseous substances, particulate matters and heavy metals are accounted for. Also heavy metal emissions to soil are included. For petrol cars platinum emissions are accounted for.
Date	2000
Geography	Data refers to average transport conditions in Europe (EU 15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the UK).
Technology	Diesel and petrol engine concepts. For emission data of gaseous substances different emission control standards are accounted for.
Source	Spielmann M. (2003). Life Cycle Inventories of Transport Services. Final report No. 14 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

11 USE

11.1 ASSUMPTIONS

11.1.1 Lifespan

Carrefour provides a 5-year guarantee with each teak garden chair. However, this relates more to the timescale of availability of the metal hardware than the actual lifespan of the chair, as teak is a very durable species, with a lifespan of more than 100 years, in theory.

The average lifetime of wood products in Germany has been cited to be 10 years for low price furniture and 30 years for high price furniture (1). Based on this information, an average lifespan of 20 years was assumed for the teak chair.

11.1.2 Maintenance Requirements

Two, alternative scenarios for maintenance are provided by Carrefour in their instructions to consumers. The first involves leaving the chair to age naturally: *"use sand paper to remove stains as necessary. If mould develops wash with a light detergent, leave to dry and sandpaper"*. The second involves protecting the chair with oil: *"wash chair, sand paper, leave to dry and apply a fine coat of teak oil 1-2 times per year. Repeat the sanding and washing process every 3 years"*.

A number of assumptions were made regarding the quantities of sand paper, water, detergent and oil needed to carry out maintenance. From these, an average input per year was determined and the material usage over the assumed 20-year lifespan was calculated.

(1) CEPI (2002). Management of Paper and Cardboard Packaging waste in Western Europe, 1990-2002. CEPI, New Cronos, Wastebase: Cited in Joconsen et al (2004). Inventory of Existing Information on recycling of selected waste materials. EEA.

Table 11.1 ***Maintenance Input Requirements***

Input	Age naturally input per year	Protect with oil input per year	Average input per year	Input over 20 years	LCI Process data used
Sand Paper	10g	10 g	10 g	0.2 kg	See Section E6
Water	3 litres	1 litre	2 litres	40 litres	n/a – elementary flow
Detergent	10 g			0.1 kg	ECOINVENT v1.01, soap, at plant
Teak Oil		50 g	25 g	0.5 kg	ECOINVENT v1.01, crude palm oil, at plant

11.1.3 *Packaging Disposal*

It was assumed that the chair's cardboard packaging is disposed of on purchase of the chair. There are a number of alternative waste treatment routes that this could take: landfill; incineration; or recycling. The choice of input inventory data for the cardboard packaging (*Section E7*) involved production with a mix of recycled and virgin fibres. As a result it is considered that a degree of cardboard recycling has already been taken into account in the assessment, and only the impacts associated with landfill and incineration will be considered in this step.

It was assumed that the ratio of landfill:incineration was 78:22 (1) and that the incineration produces heat and electricity that will offset heat and electricity generation using fossil fuels (2) .

All disposal assumptions are detailed in *Table 11.2*.

Table 11.2 ***Cardboard Packaging Disposal***

Flow	Quantity	Unit	LCI Process data used
Packaging waste to landfill	0.2535	kg	ECOINVENT v1.01, disposal, packaging cardboard, 19.6% water, to sanitary landfill
Packaging waste to incineration	0.0715	kg	ECOINVENT v1.01, disposal, packaging cardboard, 19.6% water, to municipal incineration
Electricity generated in incinerator (offset)	0.020006	kWh	ECOINVENT v1.01, electricity, medium voltage, at grid
Heat generated in incinerator (offset)	0.154726	MJ	ECOINVENT v1.01, heat, at cogen 200kWe lean burn, allocation heat
Transport to waste management facility	50	km	ECOINVENT v1.01, transport, municipal waste collection, lorry 21t

(1) European Topic Centre on Resource and Waste Management
(2) Figures calculated from Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG - Average energy outputs from disposal of 1 kg waste in modern EU MSWI (0.2798 kWh electricity, 2.164 MJ heat)

11.2 METADATA

11.2.1 Soap

Table 11.3 ECOINVENT Metadata, Soap

Name	Soap, at plant
Location	Europe
Unit	kg
Included Processes/ Description	This module contains material and energy input, production of waste and emissions for the production of soap out of fatty acids from palm and coconut oil. Transports and infrastructure have been estimated. No water consumption included. Data based on the ECOSOL study of the European surfactant industry. Allocations in multi-output processes were made, using the relative mass outputs of products.
Date	2000
Geography	Data based on the European fatty alcohol sulfonate production
Technology	Average technology for the production of soap out of a blend of fatty acids from palm and coconut oil, representing typical European production mix in the mid 90s. The ratio of short to long fatty acid chains is 20:80, the moisture 13%.
Comment of representativeness	data out of ECOSOL study of European Surfactant Industry. Common translation rules used, reported in Chemical report (Althaus et al. 2003).
Source	Zah R. (2003). Life Cycle Inventories of Detergents. Final report No. 12 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

11.2.2 Teak Oil

Table 11.4 ECOINVENT Metadata, Palm Oil

Name	Crude palm oil, at plant
Location	Malaysia
Unit	kg
Included Processes/ Description	This module contains material input, production of waste and emissions. It is assumed that the energy production uses 100% internally produced waste as fuel and therefore no energy input is shown. Water consumption and infrastructure have been estimated.
Date	1995
Geography	Data based on palm oil mills in Malaysia
Technology	Average technology, typical for Malaysian conditions in the mid 90s

Name	Crude palm oil, at plant
Comment of representativeness	data out of ECOSOL study of European Surfactant Industry. Common translation rules used, reported in Chemical report (Althaus et al. 2003).
Source	Zah R. (2003). Life Cycle Inventories of Detergents. Final report No. 12 ecoinvent 2000. Dübendorf, CH, Swiss Centre for LCI, UNS

11.2.3 *Packaging to Landfill*

Table 11.5 ECOINVENT Metadata, Packaging to Landfill

Name	Disposal, packaging cardboard, 19.6% water, to sanitary landfill
Location	Switzerland
Unit	kg
Included Processes/ Description	Waste-specific short-term emissions to air via landfill gas incineration and landfill leachate. Burdens from treatment of short-term leachate (0-100a) in wastewater treatment plant (including WWTP sludge disposal in municipal incinerator). Long-term emissions from landfill to groundwater (after base lining failure). Inventoried waste contains 100% cardboard; . waste composition (wet, in ppm): upper heating value 17.91 MJ/kg; lower heating value 15.92 MJ/kg; H2O 104370; O 392680; H 57791; C 433270; S 1776.8; N 2583.5; P n.a.; B n.a.; Cl 7173.3; Br n.a.; F n.a.; I n.a.; Ag n.a.; As 1.168; Ba 57.193; Cd 0.93313; Co 0.91806; Cr 9.2403; Cu 35.113; Hg 0.30131; Mn 95.196; Mo n.a.; Ni 10.64; Pb 28.963; Sb 0.0046044; Se 3.1073; Sn 6.7521; V n.a.; Zn 63.333; Be 1.1299; Sc n.a.; Sr 45.009; Ti n.a.; Tl n.a.; W n.a.; Si n.a.; Fe n.a.; Ca n.a.; Al n.a.; K n.a.; Mg n.a.; Na n.a.; Share of carbon in waste that is biogenic 100%. Overall degradability of waste during 100 years: 32.44%.
Date	2000
Geography	Technology encountered in Switzerland in 2000. Landfill includes base seal, leachate collection system, and treatment of leachate in municipal wastewater treatment plant.
Technology	Swiss municipal sanitary landfill for biogenic or untreated municipal waste ('reactive organic landfill'). Landfill gas and leachate collection system. Recultivation and monitoring for 150 years after closure.
Comment of representativeness	Landfill model based on observed leachate concentrations in literature. Extrapolated to 60'000 years heeding chemical characteristics. Initial waste composition from various literature sources.
Source	Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG

11.2.4 Packaging to Incinerator

Table 11.6 ECOINVENT Metadata, Packaging to Incinerator

Name	Disposal, packaging cardboard, 19.6% water, to municipal incineration
Location	Switzerland
Unit	kg
Included Processes/ Description	waste-specific air and water emissions from incineration, auxiliary material consumption for flue gas cleaning. Short-term emissions to river water and long-term emissions to ground water from slag compartment (from bottom slag) and residual material landfill (from solidified fly ashes and scrubber sludge). Process energy demands for MSWI. Inventoried waste contains 100% cardboard; . waste composition (wet, in ppm): upper heating value 17.91 MJ/kg; lower heating value 15.92 MJ/kg; H2O 104370; O 392680; H 57791; C 433270; S 1776.8; N 2583.5; P n.a.; B n.a.; Cl 7173.3; Br n.a.; F n.a.; I n.a.; Ag n.a.; As 1.168; Ba 57.193; Cd 0.93313; Co 0.91806; Cr 9.2403; Cu 35.113; Hg 0.30131; Mn 95.196; Mo n.a.; Ni 10.64; Pb 28.963; Sb 0.0046044; Se 3.1073; Sn 6.7521; V n.a.; Zn 63.333; Be 1.1299; Sc n.a.; Sr 45.009; Ti n.a.; Tl n.a.; W n.a.; Si n.a.; Fe n.a.; Ca n.a.; Al n.a.; K n.a.; Mg n.a.; Na n.a.; Share of carbon in waste that is biogenic 100%. Overall degradability of waste during 100 years: 32.44%.
Date	2000
Geography	Specific to the technology mix encountered in Switzerland in 2000. Well applicable to modern incineration practices in Europe, North America or Japan.
Technology	average Swiss MSWI plants in 2000 with electrostatic precipitator for fly ash (ESP), wet flue gas scrubber and 29.4% SNCR , 32.2% SCR-high dust , 24.6% SCR-low dust -DeNOx facilities and 13.8% without Denox (by burnt waste, according to Swiss average). Share of waste incinerated in plants with magnetic scrap separation from slag : 50%. Gross electric efficiency technology mix 12.997% and Gross thermal efficiency technology mix 25.57%
Comment of representativeness	waste-specific calculation based on literature data
Source	Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG

11.2.5 Electricity Offset

Table 11.7 ECOINVENT Metadata, Electricity Offset

Name	Electricity, medium voltage, at grid
Location	France
Unit	kWh
Included Processes/ Description	This dataset describes the transformation high to medium voltage, the transmission of electricity at medium voltage. Included are electricity losses and direct SF6-emissions to air.

Name	Electricity, medium voltage, at grid
Date	2000
Geography	The calculations are based on Swiss data. Specific SF6-Emissions (percentage of SF6 stock) are based on French data.
Technology	Average technology used to transmit and distribute electricity. Includes underground and overhead lines, as well as air-, vacuum- and SF6-insulated high-to-medium voltage switching stations.
Comment on representativeness	Attribution of total losses to losses on medium voltage level is based on assumptions.
Source	Frischknecht, R. and Faist Emmenegger, M. (2003). Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, PSI

11.2.6 *Heat Offset*

Table 11.8 ECOINVENT Metadata, Heat Offset

Name	Heat, at cogen 200kWe lean burn, allocation heat
Location	Switzerland
Unit	MJ
Included Processes/ Description	The module includes fuel input, infrastructure, emissions to air, and substances needed for operation. The multi-output process 'natural gas, burned in cogen 200kWe lean burn, allocation heat' delivers the coproducts 'heat, at cogen 200kWe lean burn, allocation heat' and 'electricity, at cogen 200kWe lean burn, allocation heat'.
Date	2000
Geography	Emissions and efficiencies adjusted to Swiss emission regulation (LRV, Luftreinhalteverordnung) valid in year 2000.
Technology	Average technology available on market.
Comment on representativeness	Literature. Manufacturer information.
Source	Heck, T. (2003). Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, PSI

11.2.7 *Transport to Waste Treatment Facility*

Table 11.9 ECOINVENT Metadata, Transport to Waste Treatment Facility

Name	Transport, municipal waste collection, lorry 21t
Location	Switzerland
Unit	tkm
Included Processes/ Description	Diesel fuel consumption, air emissions from fuel combustion for Stop&Go driving, tyre abrasion, brake lining abrasion, road abrasion and re-suspended road dust. based on a vehicle lifetime of 540'000 vehicle-kilometres
Date	2000

Name	Transport, municipal waste collection, lorry 21t
Geography	Fuel consumption and uncertainty derived from literature values for settlement structure in Swiss and German municipalities.
Technology	Waste collection and hydraulic compression vehicle. Gross load capacity 8.2 tons. Load factor 50%. Average load 4.1 tons. Emissions extrapolated from data for lorry 16t class (ecoinvent 2000 report No. 14). Adaptations for air emissions to Stop&Go driving from average driving emission factors.
Comment of representativeness	fuel consumption from specific literature data. Rest extrapolated from lorry 16t class (ecoinvent report No. 14).
Source	Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG

12 END OF LIFE

12.1 ASSUMPTIONS

There are a number of alternative waste treatment routes that the chair could take at the end of its life: landfill; incineration; or recycling. Assumptions relating to choice of disposal route are detailed in Table 12.1 below. The sensitivity of results to these assumed proportions will be tested during sensitivity analyses.

Table 12.1 Chair Disposal Routes

Possible Alternatives	Assumed Proportion	Notes
Recycling	0%	Recycling into particle boards is not considered to be an option for the teak chair. Most wood collected across Europe e.g. in Belgium is split into "contaminated" and "fresh wood". Wood collected from households mostly contains (physical) contaminants like PCV top coats, varnishes, dirt (e.g. sand, grit, plastic foils). Although teak is not treated in this way, selectively separating teak from this flow would be very costly and moreover, unless marked otherwise, it would be separated as "suspect", because collectors would think it could be preservative treated because of its colour (CEI-Bois, personal communication). The German classification considers 4 classes of recovered wood: AI - uncontaminated, only mechanically processed, AII - wood with glues, lacquers etc. but without preservatives, AIII - wood contaminated with preservatives, AIV - wood contaminated with very toxic preservatives (e.g. Mercury). Only class AI is considered suitable for recycling (1). The teak chair under consideration would fall into class AII due to the use of glues in the assembly process.
Landfill	78%	European Topic Centre on Resource and Waste Management(2) states that in the EU up to 57% of municipal waste is landfilled and up to 16% of municipal waste is incinerated or otherwise combusted for energy recovery. Discounting recycling (as this is not a feasible route for contaminated wood products), this relates to an approximate ratio landfill:incineration of 3.5:1 and this ratio was assumed for the disposal of the teak chair.
Waste incineration	22%	European Topic Centre on Resource and Waste Management (3) states that in the EU up to 57% of municipal waste is landfilled and up to 16% of municipal waste is incinerated or otherwise combusted for energy recovery. Discounting recycling (as this is not a feasible route for contaminated wood products), this relates to an approximate ratio landfill:incineration of 3.5:1 and this ratio was assumed for the disposal of the teak chair.

(1) Fruhwald A (2005). End of Life Strategies using an LCA Approach. COST E31/37, University of Hamburg, Centre for Wood Science and Technology.
(2) http://waste.eionet.eu.int/waste
(3) http://waste.eionet.eu.int/waste

It was assumed that incineration produces heat and electricity that will offset heat and electricity generation using fossil fuels [(1)].

Biogenic emissions of carbon dioxide during incineration have been discounted from the assessment (see *Section 2.1.2*).

All disposal assumptions are detailed in *Table 12.2*.

Table 12.2 ***Chair Disposal***

Flow	Quantity	Unit	LCI Process data used
Wood waste to landfill	4.6	kg	Section E9
Wood waste to incineration	1.3	kg	ECOINVENT v1.01, disposal, wood untreated, 20% water, to municipal incineration
Electricity generated in incinerator (offset)	0.3632	kWh	See Section E11
Heat generated in incinerator (offset)	2.809	MJ	See Section E11
Transport to waste management facility	50	km	See Section E11

12.2 METADATA

12.2.1 *Wood Waste to Incinerator*

Table 12.3 ***ECOINVENT Metadata, Wood Waste to Incinerator***

Name	Disposal, wood untreated, 20% water, to municipal incineration
Location	Switzerland
Unit	kg

(1) Figures calculated from Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG - Average energy outputs from disposal of 1 kg waste in modern EU MSWI (0.2798 kWh electricity, 2.164 MJ heat)

Name	Disposal, wood untreated, 20% water, to municipal incineration
Included Processes/ Description	waste-specific air and water emissions from incineration, auxiliary material consumption for flue gas cleaning. Short-term emissions to river water and long-term emissions to ground water from slag compartment (from bottom slag) and residual material landfill (from solidified fly ashes and scrubber sludge). Process energy demands for MSWI. Inventoried waste contains 100% natural wood; . waste composition (wet, in ppm): upper heating value 15.36 MJ/kg; lower heating value 13.99 MJ/kg; H2O 174080; O 372180; H 50163; C 401470; S 125.51; N 986.98; P 108.97; B 2.1107; Cl 330.95; Br n.a.; F 21.106; I n.a.; Ag n.a.; As 0.42213; Ba n.a.; Cd 0.20051; Co 0.086772; Cr 0.65782; Cu 4.1482; Hg 0.31976; Mn 53.118; Mo 0.8302; Ni 0.55581; Pb 27.868; Sb n.a.; Se n.a.; Sn n.a.; V n.a.; Zn 17.807; Be n.a.; Sc n.a.; Sr n.a.; Ti n.a.; Tl n.a.; W n.a.; Si n.a.; Fe 15.479; Ca 130.89; Al 6.3322; K 65.412; Mg 197.56; Na 14.071; Share of carbon in waste that is biogenic 100%. Share of iron in waste that is metallic/recyclable 0%. Net energy produced in MSWI: 1.3MJ/kg waste electric energy and 2.74MJ/kg waste thermal energy Allocation of energy production: no substitution or expansion. Total burden allocated to waste disposal function of MSWI. One kg of this waste produces 0.004126 kg of slag and 0.001698 kg of residues, which are landfilled. Additional solidification with 0.0006793 kg of cement.
Date	2000
Geography	Specific to the technology mix encountered in Switzerland in 2000. Well applicable to modern incineration practices in Europe, North America or Japan.
Technology	average Swiss MSWI plants in 2000 with electrostatic precipitator for fly ash (ESP), wet flue gas scrubber and 29.4% SNCR , 32.2% SCR-high dust , 24.6% SCR-low dust -DeNOx facilities and 13.8% without Denox (by burnt waste, according to Swiss average). Share of waste incinerated in plants with magnetic scrap separation from slag : 50%. Gross electric efficiency technology mix 12.997% and Gross thermal efficiency technology mix 25.57%
Comment of representativeness	waste-specific calculation based on literature data
Source	Doka G. (2003). Life Cycle Inventories of Waste Treatment Services. Final report No. 13 ecoinvent 2000. Dübendorf and Villigen, CH, Swiss Centre for LCI, EMPA-SG

Table 13.1 details the quantitative and qualitative impact values for the whole life cycle of the teak chair. These are presented in *Section 3.1.3* of the report, as a percentage contribution of each activity to the total impact in each category. Refer to *Annex C* for details of the methodology used to generate qualitative impact values.

Table 13.1 Environmental Impact Matrix

	Resource Depletion Cumulative Energy Demand (Non-Renewable) (MJ-equivalents)	Resource Depletion Cumulative Energy Demand (Renewable) (MJ-equivalents)	Water Resource Use (m3)	Global Warming (Kg CO2 equivalents	Acidification & Eutrophication Ecoindicator 99 ecopoints	Ecotoxicity Ecoindicator 99 ecopoints	Human Health	Land Transformation	Social Issues	Bio-diversity	Erosion
Teak (log) production	26.43	229.86	0.0012	1.63	0.005	0.0035	73	73	219	110	110
Brass Fastening production	3.18	0.79	0.005	0.2	0.0018	0.053	1	1	1	1	1
Glue production	2.94	0.099	0.00023	0.13	0.00027	0.00006	0	0	0	0	0
Oil/lubricant production	0.6	0.0045	0.00002	0.0074	0.00001	0.00002	0	0	0	0	0
Sand Paper Production	0.15	0.45	0.00003	-0.0097	0.00003	0.00004	1	1	1	1	1
Packaging material production	5.92	2.03	0.0032	0.33	0.00051	0.00091	4	4	4	4	4
Teak Component Manufacture	7.38	3.47	0.0091	0.62	0.00075	0.0011	49	6	6	6	6
Chair Assembly	7.93	3.13	0.0022	0.47	0.0058	0.0008	12	6	6	6	6
Distribution	91.62	1.15	0.0047	6.13	0.019	0.019	75	75	75	75	75
Use	5.63	9.2	0.041	1.15	0.0022	0.0019	6	6	6	6	6
End of life	-3.56	-0.18	-0.00038	0.019	0.00061	0.00086	53	53	53	53	53
Total	148.34	250.01	0.066	10.69	0.031	0.088	275	226	372	263	263

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