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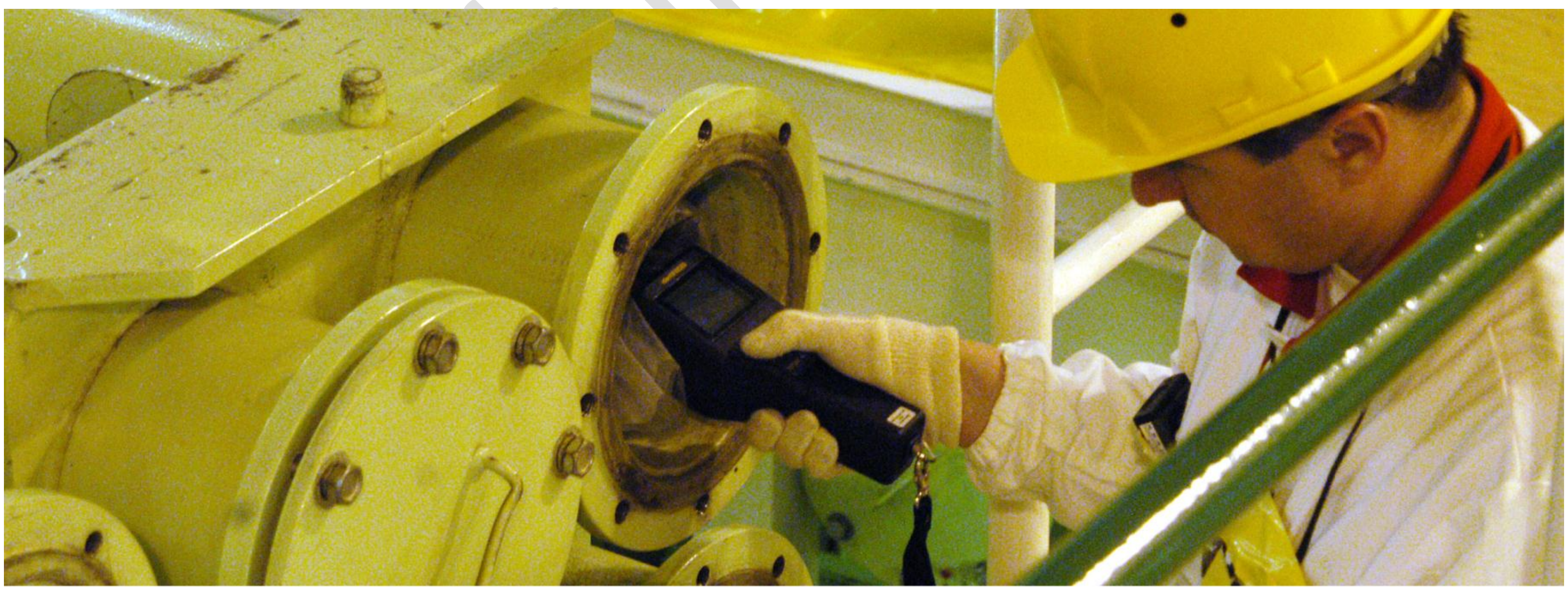
BACKGROUND REPORT

Revision of Ecolabel and Green Public Procurement criteria for the product group

Wooden Furniture

September 2013



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ACRONYMS

ABS	Acrylonitrile Butadiene Styrene
AP	Acification Potential
ATP	Adaptation Technical Progress
CLP	Classification, Labelling and Packaging
DSD	Dangerous Substance Directive
DPD	Dangerous Preparations Directive
EEA	European Economic Area
EP	Eutrophication Potential
EPD	Environmental Product Declaration
EoL	End of Life
EXPVAL	Export value
GWP	Global Warming Potential
GDP	Gross domestic product
GPP	Green Public Procurement
HS	Codes Harmonized System Codes
HTP	Human Toxicity Potential
IMPVAL	Import value
LCA	Life Cycle Assessment
MDA	4,4-Diaminodiphenylmethane
MDF	Medium Density Fibreboard
MSs	Member States
ODP	Ozone Depletion Potential
PCR	Product Category Rules
PE	Polyethylene
PEF	Product Environmental Footprint
PET	Polyethylene terephthalate
PLA	Polylactic acid
POCP	Photochemical Ozone Creation Potential
PP	Polypropylene
PRODCOM	PRODuction COMmunautaire (Community Production)
PRODVAL	Production value
PS	Polystyrene
PVA	Polyvinyl acetate
PVC	Polyvinyl chloride
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SME	Small and Medium Enterprise
tbd	to be defined
VOC	Volatile Organic Compound

1. SUMMARY

The criteria of the EU Ecolabel for Wooden Furniture 2009/894/EC: Commission Decision of 30 November 2009 and Green Public Procurement (GPP) criteria for wooden furniture are under revision. The main objective of this project is to revise Ecolabel and Green Public Procurement criteria for wooden furniture considering the current criteria. The need for revision is justified either because some criterion must be amended or withdrawn and also to extend and promote the use of the most environmentally friendly products.

The participation of all relevant interested parties such as competent bodies, NGO´s, associations, manufacturers, importers and retailers will be very important to determine the main shortcomings of current EU Ecolabel and GPP criteria.

The revision process will also take into account the possible expansion of the scope for this product group and consequently the revision of the criteria to other types of furniture. Hence, one of the goals of the revision is to obtain simplified criteria addressing the most important environmental impacts of furniture in a life cycle perspective.

In this report, a preliminary check to analyze the scope, criteria and existing definition for wooden furniture has been carried out. The report is based on the following gathered data regarding furniture sector:

- ✓Legislation
- ✓European Standards
- ✓Other environmental labelling
- ✓Market analysis
- ✓Analysis of Life Cycle Assessment studies
- ✓Technical analysis. Including the assessment of hazardous substances.

Green Public Procurement (GPP) criteria for furniture will also be revised in order to consider the most significant environmental impacts, and will be based on data from an evidence base, on Ecolabel criteria and on information collected from stakeholders of industry, civil society and Member States. The proposed recommendations will be according core and comprehensive criteria. Core criteria will address the most significant environmental impacts and comprehensive criteria will be more specific and aimed to ensure that the authorities purchase the best environmental products available on the market.

Market analysis

The market report characterizes the relevant European furniture market and its tendencies at a quantitative and qualitative level. The EU-27 furniture production covers over 20% of the world total with Italy and Germany the third and fourth major producers over the world, after China and the United States. More than half (55%) of the world furniture production takes place in middle and low income countries.

The most common material used in the furniture sector is wood (56% of the pieces of furniture produced in the EU 27 in 2011 are based on wood, which represent 56% of the production value). Metal is the second material most commonly used (12% of items produced and 17% of the production value), followed by plastic (6% of items produced and 1% of the production value) and other materials (1% of items produced and negligible production value) like bamboo, cannier, osier, glass. The remaining 25% represents materials which are not specified within the PRODCOM database. Although wood is the most common material used, most pieces of furniture also contain other materials. The current ecolabel provides a requirement of 90% content by weight of wood or wooden-based material. This severely limits the market penetration of the EU Ecolabel for furniture products.

Regarding the function of furniture, 18% of the pieces of furniture manufactured in 2011 in the EU-27 are used in dining rooms, living rooms and bedrooms (20% by value). Other important production subsectors are kitchen furniture (15% by number, 18% by value), non-upholstered seats (14% by number, 8% by value), office furniture (9% by number, 12% by value), upholstered seats (8% by number, 15% by value), mattress supports (3% by number, 2% by value) and wooden furniture for shops (2% by number, 6% by value). About 31% (19% by value) is not specified regarding function.

The total furniture imports and exports in the EU27 significantly declined in the period between 2008 and 2009. However, signs of recovering imports were observed in 2011. The largest European furniture exporters are Italy and Germany (42% of total EU27), while the largest importer is Germany (21% of total EU27). China is the major supplier to the EU27 (55.4 % of EU imports). In that sense, the competition from Asia, and most importantly China, is intensifying, and the pressure on prices is high.

The uptake of EU core GPP criteria varies across countries. For the period 2009-2010, Denmark was the top performer as regards the inclusion of all GPP core criteria, with a share of 50%, followed by France (44%) and Belgium (40%). Only 14% of the furniture contracts respond to EU core GPP criteria, thus not meeting the target of 50% set at the EU level by 2010.

Life Cycle Assessment

Life Cycle Assessment is a tool to analyse the potential environmental impact of a product during all life stages, from raw materials extraction to the end of life. A comprehensive screening of published LCA studies for furniture products has been carried out. Thirteen LCA studies were selected for this revision based on a set of quality requirements. These studies provide useful insight in the technical and environmental analysis of furniture products. Moreover, 35 verified environmental product declarations (EPDs) from international EPD schemes are available for furniture products (25 for office chairs , 5 for wooden panels/boards, 4 for domestic chairs and 1 for tables). Apart from these documents, other studies proved to be useful to handle issues of relevance for the revision process (e.g. hazardous substances).

Different types of furniture have been analysed: wooden panels, office and school furniture and domestic furniture.

The selected studies provide outcomes regarding:

- -Key environmental impacts of different furniture product systems
- -Relative contribution of different life stages to the impacts (materials, manufacturing, packaging, distribution, use and end-of-use) and main sources of concern.
- -Improvement potential options (design, raw materials, production processes, distribution, life duration and end of life scenarios).

The main outcomes from the LCA review and the analysis of ecodesign measures can be summarised as follows:

- Materials. Materials and their processing have the biggest share in most impact categories. Impacts for metals and plastics are generally higher than for wood but durability of materials is an important issue to take into account. A lot of energy is embedded in virgin metals. As such, burdens can be decreased by improving resource efficiency and recycling. Wooden materials also demand energy in their production processes, for instance for sawing and drying. Transport of materials is less important than processing, but it could become more relevant when non-local materials are used. Improvement potential options result from using more sustainable materials (renewable, recyclable or minimizing the use of hazardous substances).

- Manufacturing. Manufacturing seems to be the second most relevant stage of the lifecycle. Energy consumption is the most important parameter, especially in processes where heating is used, such as drying in painting and coating. The use of adhesives and coatings can be an important source of concern in certain impact categories.

- Packaging. Packaging is assessed in terms of materials used and impacts related. In general its environmental load is low but not negligible. Improvement potential options have been found if packaging is optimized.

- Distribution. Distribution is not deeply investigated since normally only average scenarios are used. However, this seems to be an issue of secondary importance only for some impact categories (e.g. ODP). Improvement potential options have been found for distribution phase (e.g. optimization of logistics, vehicles, or decreasing distances of transport).
- Use. When maintenance is included in the assessment it results to have negligible impacts. Durability is instead a key issue to minimize the impacts of furniture products.
- End-of-Life. End-of-life impacts vary depending of the waste treatment scenarios. Burdens due to landfilling are relatively low compared to the other lifecycle stages. However, significant improvement potential can be achieved by reusing and recycling products or parts of them or by recovering the energy content of waste.

Hazardous substances

Ecolabelled furniture should not contain harmful substances. Information on the most commonly used substances in the furniture industry has been provided. Based on the information obtained from ESIS, ECHA, CLP, scientific literature and other ecolabels, a priority list of hazardous substances has been determined.

Scope

Based on the elements above, the following recommendation on the potential scope extension is made:

- Furniture often seems to consist of different materials. The most common materials used in the furniture sector are wood and wood-based materials, followed by metals and plastics. Therefore the product group should be expanded in order to allow for the inclusion of types of furniture most commonly used.

- According to the LCA screening, it will be important to set criteria for the different material types which may be used in furniture. The focus should be on the most important environmental impacts associated to wood and wood-based products (such as sustainable forestry), metals, plastics and any other critical material identified along the project. Glass should be not excluded "a priori" from the scope, due to relevant impacts associated with the use of this material.

These findings on scope expansion were confirmed by the results of a questionnaire that has been addressed to the stakeholders.

Based on the results of this background report, a criteria proposal has been prepared taking into account the main outcomes referring:

- The current legislation and other Ecolabel Schemes for furniture products.

-The current situation of European market of furniture.

- The main environmental impacts of furniture products and potential improvement areas.

- The identification of hazardous substances according REACH Regulation used in this product category group and their potential impacts to human health and environment.

2. LEGAL INSTRUMENTS, STANDARDS AND SCHEMES OF RELEVANCE

There is no specific EU legislation for furniture. However, several legislation and standards related to the environment, chemicals, health and safety directly affect these products and have been identified in this report.

Regarding voluntary approaches, a growing number of furniture manufacturers are implementing environmental management schemes (e.g. EMAS) in order to improve their environmental performance. Standards, which also have a voluntary nature, are an important aspect to take into account. There is a Technical Committee on Furniture (CEN/TC 207) which develops standards on terminology issues, safety issues (e.g test methods on flammability and fire behaviour), test methods and requirements for end products, components, surfaces as well as standards on dimensional coordination. Over 70 EN standards have been published so far and there are a number of standards in development.

During the revision of the European Ecolabel for furniture a comparison was made between the following main national ecolabels in order to introduce measures to encourage harmonisation with other Ecolabel schemes:

- Milieukeur, Stichting Milieukeur, The Netherlands
- Marque NF Environnement, AFNOR, France
- ÖkoControl, Gesellschaft für Qual.Standards ökologischer Einrichtungshäuser, Germany
- Nordic Swan, Nordic Ecolabelling board, Nordic countries
- RAL-UZ 38, Blaue Engel/RAL, Germany
- UZ 06, UZ 34, Österreichische Umweltzeichen, Austria

A detailed table with all the specifications and scope established for these labels for the main materials or characteristics can be found in section 2.3.1 of this report.

2.1. Relevant European environmental policy and legislation

Several Directives and Regulations exist that may be relevant when defining criteria for furniture in order to prevent the potential harmful impacts for human health and environment. The main regulatory framework which may be relevant when defining criteria for furniture is described briefly in this section:

- **Regulation 66/2010**[1] of the European Parliament and the Council on the EU Ecolabel. The European Union Ecolabel is a voluntary environmental labelling system. It enables consumers to recognize high quality eco-friendly products.
- **Regulation (EU) 995/2010**[2] of the European parliament and of the Council laying down the obligations of operators who place timber and timber products on the market. Main obligations are:
  1) It prohibits the placing on the EU market for the first time of illegally harvested timber and products derived from such timber;
  2) It requires EU traders who pace timber products on the EU market for the first time to exercise 'due diligence'. The core of the 'due diligence' notion is that operators undertake a risk management exercise so as to minimize the risk of placing illegally harvested timber, or timber products containing illegally harvested timber, on the EU market.
  3) Once on the market, the timber and timber products may be sold on and/or transformed before they reach the final consumer. To facilitate the traceability of timber products economic operators in this part of the supply chain (referred to as traders in the regulation) have an obligation to keep records of their suppliers and customers.

This Regulation covers a wide range of timber products listed in its Annex including solid wood products, flooring, plywood, pulp and paper. Not included are recycled products, as well as printed papers such as books, magazines and newspapers.

The application of the Regulation has started on 3rd March 2013. Timber and timber products covered by valid FLEGT or CITES licenses are considered to comply with the requirements of the Regulation.

- **Council Regulation (EC) Nº 2173/2005** of 20 December 2005 on the establishment of a **FLEGT** licensing scheme for imports of timber into the European Community[3].
- **The Council Resolution of 15 December 1998 on a Forestry Strategy for the European Union[4] with subsequent communications[5]** established a framework for forest-related actions in support of sustainable forest management (SFM). It states that forest policy lies in the competence of the Member States, but that the EU can contribute to the implementation of SFM through common policies, based on the principle of subsidiarity and the concept of shared responsibility.
- **Regulation (EC) Nº 1107/2009[6]** of 21 October 2009 concerning the placing of plant protection products on the market. This Regulation lays down rules for the authorisation of plant protection products in commercial form and for their placing on the market, use and control within the Community. This Regulation increases the level of health and environmental protection, contributes to better protection of agricultural production, and enlarges and consolidates the internal market for plant protection products.

- **REACH[7]** regulation. **Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH),** establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EC) N° 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.

  REACH does not allow marketing of a chemical substance if it does not have appropriate registration, which has to be carried out by every legal entity that manufacture or import from outside of the European Union substances on their own, in preparations or in articles in quantities of 1 tonne or above per year. REACH places responsibility on industry to manage the risks that chemicals may pose to human health and environment, as well as to provide safety information that would be passed down the supply chain. The companies that do not undertake this procedure, will not be able to produce, sell or use their products and would consequently be forced to stop their activity.

  In addition to registration, REACH regulates other procedures such as the management of the risk and hazardous properties of the substance, authorisation of substances of very high concern (carcinogenic, mutagenic and/or toxic for reproduction, persistent, bioaccumulative and toxic or very persistent and very bioaccumulative) and the restriction on the manufacturing, placing on the market and use of certain dangerous substances, preparations and articles when an unacceptable risk to human health or the environment exists.

  Certain substances[8] that may cause serious and often irreversible effects on human health and the environment can be identified as Substances of Very High Concern (SVHC). REACH aims at ensuring that the risks resulting from the use of SVHCs are controlled and that the substances are replaced where possible. A Member State, or ECHA[1] on request of the European Commission, can propose a substance to be identified as an SVHC. Placing on the market and use of SVHC included in the Authorisation List (Annex XIV of REACH regulation), requires authorisation. A manufacturer, importer or downstream user can apply for the authorisation. Applications for authorisation are

[1] European Chemicals Agency.

submitted to ECHA. At the end of the authorisation process, which includes a public consultation and the development of opinions by ECHA´s Committees on Risk Assessment and Socio-economic Analysis, the European Commission decides on the granting or refusing of authorisations.

The identification of a substance as Substance of Very High Concern and its inclusion in the Candidate List[9] is the first step of the authorisation procedure. Companies may have immediate legal obligations following such inclusion which are linked to the listed substances on its own, in preparations and articles. Chemicals that are restricted are referred to under Article 57 and listed in Annex XVII[10] of REACH, while Article 59 (1) sets out a procedure for the recommendation of chemicals considered posing risks to human health and/or the environment.

- **Directive 1999/13/EC[11]** of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations.
- **Directive 2004/42/EC[12]** of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC.
- **Council Directive 96/61/EC[13]** of 24 September 1996 concerning integrated pollution prevention and control (IPPC).
- **Directive 2002/45/EC[14]** of 25 June 2002 amending for the twentieth time Council Directive 76/769/EEC applies more specifically to leather production, and prohibits the marketing of substances and preparations for the fat liquoring of leather containin C10-C13 chloro-alkanes in concentrations above 1%.
- **Directive 1999/44/EC[15]** of 25 May 1999 on certain aspects of the sale of consumer goods and associated guarantees.
- **Directive 2008/98/EC[16]** on waste. Furniture production generates waste, for example waste from wood processing and the production of panels and furniture, wood preservation wastes and wastes from the use of paints and varnishes. This Directive lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste, and by reducing overall impacts of resource use and improving the efficiency of such use.
- **Directive 94/62/EC[17]** of 20 December 1994 on packaging and packaging waste. This Directive aims to prevent or reduce the impact of packaging and packaging waste on the environment. It contains provisions on the prevention of packaging waste, on the re-use of packaging and on the recovery and recycling of packaging waste.
- **Directive 67/548/EEC[18]** of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances. This Directive sets out the criteria and the procedure to harmonise the classification and labelling of substances.
- **Directive 1999/45/EC[19]** of 31 May 1999 concerning the approximation of the laws, regulations and administrative provisions of the Members States relating to the classification, packaging and labelling of dangerous preparations. This directive sets out rules on how to classify and label preparations for human health and environmental hazards.
- **CLP: Regulation 1272/2008**[20] **on classification, labelling and packaging of substances and mixtures**. On 20 January 2009 this regulation entered into force. It aligns existing EU legislation to the United Nations Globally Harmonised System (GHS)[21]. The date from which substance classification and labelling must be consistent with the new rules was December 2010 and for mixtures will be June 2015. At that time, the CLP Regulation will replace fully the Dangerous Substance Directive (67/548/EC) and the Dangerous Preparations Directive (1999/45/EC).
- **Regulation EU 528/2012**[22] of the European Parliament and of the Council concerning the making available on the market and use of biocidal products. It will repeal and replace from September 2013 on the Directive 98/8/EC[23], concerning the placing of biocidal products on the market. The Regulation will maintain the two-step process of approval while providing for the possibility that some biocidal products are authorised at the Union level. A key

element in this new Regulation is the extension of the scope to cover articles and materials treated with biocidal products (e.g. furniture treated with wood preservatives), which are imported from third countries;

2.2. European Standards

Different European standards are of relevance for the furniture sector. A full list of standards will be completed in the next draft of this report. The following committees and organizations have been identified so far:

- CEN Committee CEN TC 207 Furniture
- CEN Committee CEN TC 136 Sports, playground and other recreational facilities and equipment
- CEN Committee CEN TC 38 Durability of wood and wood-based products
- CEN Committee CEN TC 112 Wood-based panels
- European Panel Federation's (EPF) "Industry Standard for delivery conditions of recycled wood "
- EOTA – European Organization for Technical Approvals (Endorsed ETAGs: European Technical Approvals)

2.3. Other environmental labelling and sustainable products procurement schemes

Several countries have their own environmental labels on furniture products. However, there are differences in the focus and the scope of these labels.

In this section we examine the most known ecolabels from around the world for this product category[24]:

Table 1. Summary of other ecolabels applicable to furniture

ECOLABEL NAME	LOGO	REGION	PRODUCT CATEGORY	DATE OF ADOPTION
ANAB - Architettura Naturale		Italy	Furniture	1999
CertiPUR		Belgium	Furniture	2005
CertiPUR-US		United States	Furniture	2002
Cradle to Cradle Certified		United States	Furniture	2005
Eco3Home		United States	Furniture	2010

ECOLABEL NAME	LOGO	REGION	PRODUCT CATEGORY	DATE OF ADOPTION
EcoLogo		United States	Furniture	1988
Ekolabel Indonesia		Indonesia	Furniture	2006
Ekologicky setrny vyrobek / Environmentally Friendly Product		Czech Republic	Furniture	1994
Environmental Product Declaration		-	Furniture	1999
Global GreenTag Certified		Australia	Furniture	2010
Good Environmental Choice Australia (GECA)		Australia	Furniture	2001
Good Shopping Guide Ethical Award		United Kingdom	Furniture	2001
Greencircle		United States	Furniture	2010
Indoor Air Comfort		-	Furniture	2010
Lembaga Indonesia Ekolabel		Indonesia	Furniture	Unknown

ECOLABEL NAME	LOGO	REGION	PRODUCT CATEGORY	DATE OF ADOPTION
Level		United States	Furniture	2009
Milieukeur: the Dutch environmental quality label		Netherlands	Furniture	1992
NF-Environnement Mark		France	FURNITURE (NF 217) / DOMESTIC FURNITURE (NF022)/ OUTDOOR FURNITURE (NF 024) / OFFICE FURNITURE AND ACCESSORIES (NF 293) / CONTRACT FURNITURE (NF 372)	1991[2]
NSF/ANSI 336: Sustainability Assessment for Commercial Furnishings Fabric		United States	Furniture	2010
ÖkoControl		Germany	Furniture	1994
Programme for the Endorsement of Forest Certification (PEFC) schemes		Switzerland	Building products	1999
SCS Indoor Advantage		United States	Furniture	2007
SCS Sustainable Choice		United States	Furniture	Unknown

[2] Latest updated version for NF217 (furniture) was on 19/06/2012,

ECOLABEL NAME	LOGO	REGION	PRODUCT CATEGORY	DATE OF ADOPTION
SFC Member Seal		United States	Furniture	2006
Sourcemap		Unknown	Furniture	2011
SustentaX		United States	Furniture	2008
UL Environment		United States	Furniture	2007
Nordic Ecolabel or Swan		Denmark, Finland, Iceland, Norway, Sweden	Furniture and fitments / Outdoor furniture and playground equipment / Panels for the building, decorating and furniture industry	1989[3]
Blue Angel		Germany	Wood and wood-based products (RAL-UZ 38)/ upholstered furniture (RAL-UZ 117)	1978[4]
ÖSTERREICHISCHE UMWELTZEICHEN		Austria	Wooden furniture (UZ06) and office chairs (UZ34)	-

Source: Ecolabel Index[25]

A brief description of them is given below:

- **ANAB – Architettura Naturale**[26]: A certification scheme that assesses the sustainability of **building products and furniture**. Building materials must be made primarily from renewable virgin resources and secondary resources for

[3] Latest updated version for Nordic Swan (furniture and fitments) was on 19 June 2013.
[4] Latest updated version for Blue Angel wood and wood-based products (RAL-UZ 38) was on April 2011 and for upholstered furniture (RAL-UZ 117) on September 2009.

which recycling is logistically and energetically feasible. They are made from raw materials which are preferably obtained locally; they derive from a production process which does not involve use of substances hazardous to human health or the environment and they do not emit pollutants during use. Materials are supplied with information on sustainability for use by architects and users and come with installation and maintenance specifications for ensuring reduced environmental impact during both construction and use of the building.

- **CertiPUR[27]:** Is a voluntary standard to advance the safety, health and environmental (SHE) performance of flexible polyurethane foams used in **bedding and upholstered furniture** by EUROPUR, the association of European flexible polyurethane foam block manufacturers. The scheme takes into account existing standards and scientific studies related to emanations from foams, product criteria and risk assessments.

- **CertiPUR-US[28]**: Is an extension of the European CertiPUR program developed in 2002 to the United States. Home furnishings items, such as upholstered furniture and mattresses, that carry the CertiPUR-US seal contain flexible polyurethane foam products that have been tested and certified by an independent laboratory to meet specific criteria for physical performance, indoor emissions and environmental stewardship.

- **Cradle to Cradle Certified[29]**: Cradle to Cradle Certification is a third-party sustainability label that requires achievement across multiple attributes:

  – use materials that are safe for human health and the environment through all use phases

  – product and system design for material reutilization, such as recycling or composting

  – use of renewable energy

  – efficient use of water, and maximum water quality associated with production

  – company strategies for social responsibility.

  Cradle to Cradle certification is a four-tiered approach consisting of Basic, Silver, Gold, and Platinum levels. This certification program applies to materials, sub-assemblies and finished products.

- **Eco3Home[30]:** Is a label for home furnishings in the USA. Products are manufactured by companies that commit to all three initiatives (health, safety and environment) to achieve the label.

- **Ecologo[31]:** Is North America´s largest environmental standard and certification mark. Ecologo provides customers – public, corporate and consumer – with assurance that the products and services bearing the logo meet stringent standards of environmental leadership. The Ecologo Program is a Type I eco-label, as defined by the International Organization for Standardization (ISO). This means that the Program compares products/services with others in the same category, develops rigorous and scientifically relevant criteria that reflect the entire lifecycle of the product, and awards the Ecologo to those that are verified by an independent third party as complying with the criteria. The EcoLogo Program is one of two such programs in North America that has been successfully audited by the Global Ecolabelling Network (GEN) as meeting ISO 14024 standards for eco-labelling.

- **Ekolabel Indonesia[32]:** This ecolabel is found on retail goods in Indonesia. Criteria are based on scientific technical studies of the products ´environmental aspects throughout its lifecycle.

- **Ekologicky setrny vyrobek / Environmentally Friendly Product[33]:** Is the official registered label of The Czech ecolabelling programme (National Programme for Labelling Environmentally Friendly Products). In 2004 the scope of the programme was extended by the opportunity to certify services, beginning with tourist accommodation services.

At the same time, a new version of the ecolabel (Ekologicky setrna sluzba / Enviromentally Friendly Service) was introduced. At present, the Czech ecolabel can be acquired at 41 categories of products and two categories of services.

- **Environmental Product Declaration[34]:** The overall goal of the International EPD System is to communicate the environmental performance of their products (goods and services) in an understandable way.

- **Global GreenTag Certified[35]:** Is a third party, green product rating and certification system, underpinned by scientific and Life Cycle Assessment (LCA) processes. The program assesses products against worst case business as usual products in the same functional category and with the same functional purpose, based on the following impacts/benefits:

  - Product synergy
  - Greenhouse emission point (ISO 14067)
  - Human health & eco-toxicity (REACH and US EPA)
  - Life cycle assessment (ISO 14040-44)
  - Biodiversity and resource consumption
  - Corporate social responsibility (Ethics, ILO, ISO 8000 & Devel Programs)

  The Global Green Tag ecolabel rating differentiates a product within the top end of the green product market by scoring, weighting and developing and EcoPOINT Score (-1 to +1). The system provides metrics for sustainability that include “Net Positive” impacts such as carbon sequestration, net positive biodiversity or health impacts of products.

- **Good Environmental Choice Australia (GEGA)[36]:** It provides an environmental mark of recognition for a wide range of products and services that are sensitive to environmental pressures. The program has been developed for general compliance to ISO 14024 and is managed by a not-for-profit organisation utilising a national network of registered assessors.

- **Good Shopping Guide Ethical Award[37]:** The aim of the Ethical Company Organisation is to set and independent benchmark for corporate social responsibility. The Ethical Accreditation scheme enables companies and brands to display an independently-verified bill of health across the fields of people, animal welfare and the environment.

- **GreenCircle [38]:** It provides third-party certification of sustainable aspects of products and manufacturing operations. Manufacturers, suppliers, regulators, and consumers can be assured that products labeled with the GreenCircle Certified mark have been thoroughly assessed and their claim verified.

  GreenCircle Certified offers claim validation for recycled content, rapidly renewable resource content, carbon footprint reductions, and renewable energy use. Certifications are also available for a closed loop product, life cycle assessment (LCA) optimized products, and sustainable manufacturing practices.

- **Indoor Air Comfort[39]:** Eurofins "Indoor Air Comfort" product certification is an innovative tool for showing compliance with low VOC emission requirements from construction products and furniture of all relevant European specifications on two levels: Standard level "Indoor Air Comfort - certified product" shows compliance of product emissions with all legal specifications issued by authorities in the European Union. Higher level "Indoor Air Comfort GOLD - certified product" shows compliance of product emissions with the voluntary specifications issued by all relevant ecolabels and similar specifications in the EU.

- **Lembaga Indonesia Ekolabel[40]:** The Indonesian Ecolabelling Institute (LEI-Lembaga Ekolabel Indonesia) is a non-profit constituent based organization that develops forest certification systems that promote sustainable forest resource management in Indonesia.

  LEI's certification includes schemes for: 1. Natural forest certification 2. Plantation forest certification 3. Community forest certification 4. Chain of Custody (COC), a log tracking system for industries that process forest products such furniture, plywood, sawn wood and pulp and paper.

- **Level[41]:** The level brand identifies that a product has been evaluated to the multi-attribute BSR/BIFMA e3 Furniture Sustainability Standard by an independent third party certifier and its numeric marking 1, 2, or 3 indicates what threshold of certification it has achieved.

  It has been created to deliver the most open and transparent means of evaluating and communicating the environmental and social impacts of furniture products in the built environment. Taking into account a company's social actions, energy usage, material selection and human and ecosystem health impacts, level addresses how a product is sustainable from multiple perspectives.

- **Milieukeur[42]:** Milieukeur is the Dutch environmental quality label for products and services. There are Milieukeur criteria for a wide variety of food products, consumer products and services.

  The Milieukeur criteria relate to the entire life cycle of the product or service and represent an integrated approach to sustainability. The Milieukeur certification schemes cover a diverse range of sustainability issues, including raw materials, energy and water consumption, noxious substances, packaging and waste, plant protection, fertilizers, animal welfare, nature management, food safety and employee care.

- **NF-Environnement Mark[43]:** A voluntary certification mark issued by AFNOR Certification. To get the NF Environnement mark, the product must comply with ecological and fitness for purpose criteria.

  These criteria are the result of negotiations between representatives of manufacturers, consumers, environmental protection and distributor associations and public authorities. This MF-Mark is recognized by the French ministry of environment.

- **NSF/ANSI 336 Sustainability Assessment for Commercial Furnishings Fabric[44]:** This NSF ecolabel addresses the environmental, economic and social aspects of furnishing fabric products, including woven, non-woven, bonded and knitted fabrics used for upholstery (e.g. office and hotel furniture), vertical (e.g. drapery or panel systems fabric) and decorative top of bed applications (e.g. bedspreads) commonly used in institutional, hospitality and office settings. The standard also incorporates life cycle assessment criteria, which measures inputs, outputs and environmental impacts of textile products across their entire lifespan.

- **ÖkoControl [45]:** The ÖkoControl Label is given to furniture, bedding or mattresses made of natural, sustainable materials after strict tests made by independent and accredited test laboratories. It's a label guaranting the low output of dangerous emission.

- **Programme for the Endorsement of Forest Certification (PEFC) schemes[46]:** The Programme for the Endorsement of Forest Certification (PEFC) is an international non-profit, non-governmental organization dedicated to promoting Sustainable Forest Management (SFM) through independent third-party certification. It works throughout the entire forest supply chain to promote good practice in the forest and to ensure that timber and non-timber forest products are produced with respect for ecological, social and ethical standards.

- **SCS Indoor Advantage[47]:** SCS Indoor Advantage and SCS Indoor Advantage Gold certifications demonstrate that products meet indoor air quality standards pertaining to emissions that may be harmful to human health and the environment. SCS Indoor Advantage applies to furnishings and qualifies for the BIFMA furniture emissions standard, while SCS Indoor Advantage Gold certification applies to furniture plus a broader range of interior building materials such as paint, carpet, and insulation. Gold-level certification meets California Section 01350 IAQ standards for both residential and commercial application. Both certifications help products qualify for low-emitting material credits within the LEED rating systems.

- **SCS Sustainable Choice[48]:** Sustainable Choice certification ensures that carpet products meet measurable environmental performance and social responsibility criteria for continuous improvement. The certification is based on the internationally recognized standard NSF/ANSI 140 Sustainable Carpet Assessment Standard (2010). Sustainable Choice is awarded on three certification levels (Silver; Gold; Platinum) through points achieved in five requirement areas

  - public health and community impact
  - energy usage and efficiency
  - material content
  - responsible manufacturing
  - reclamation and end-of-life management

- **SFC Member Seal[49]:** The Sustainable Furnishings Council (SFC) Member Seal is a label representing those companies which have made a public and verifiable commitment to sustainability and to improvement. These companies are involved in the home furnishings industry. The Exemplary status is voluntary - all members make a public & verifiable commitment to sustainability, to transparency, and to continuous improvement.

- **Sourcemap[50]:** It supports sustainable decision-making through our platform for supply chain transparency, where producers share detailed information about their processes with their buyers and their buyers' buyers, all the way to the end consumer. A Sourcemap ecolabel points to information on a product's components and their origins, as well as optional environmental and social footprints. The information is provided and self-certified by suppliers, manufacturers, and the general public; sourcemaps can also bear third-party certifications. A suite of supply chain management and traceability solutions is also available to paying users. Scanning a Sourcemap ecolabel on a product directs consumers to an interactive map of the product's supply chain, often providing information on environmental footprint and social impact.

- **SustentaX[51]:** Is a Brazilian ecolabel that assists consumers to identify sustainable products, materials, equipments and services. Products with the SustentaX Seal are evaluated for their quality and human safety. Manufacturers must prove their social, environmental and marketing responsibilities. The independent verification process for the SustentaX Seal is based on ISO 14024.

- **UL Environment[52]:** It supports the growth and development of sustainable products, services and organizations in the global marketplace through standards development, educational services and independent third-party assessment and certification. Specific environmental solutions services UL Environment provides include environmental claims validation, sustainable products certification, energy efficiency certification, environmental product declarations and advisory services.

- **Nordic Ecolabel or Swan**[53]: Is a voluntary ecolabelling scheme that evaluates a product´s impact on the environment throughout the whole life cycle. The label guarantees among other that climate requirements are taken into account and CO_2 emissions (and other harmful gasses) are limited – where it is most relevant. The Nordic Ecolabel is available for 65 product groups including: furniture and fitments, outdoor furniture and playground equipment and panels for the building, decorating and furniture industry. The label ensures that products fulfill certain criteria using methods such as samples from independent laboratories, certificates and control visits.

- **Blue Angel**[54]**:** Is the first and oldest environment-related label for products and services in the world. It was created in 1978 on the initiative of the Federal Minister of the Interior and approved by the Ministers of the Environment of the federal government and the federal states. It considers itself as a market-conform instrument of environmental policy designed to distinguish the positive environmental features of products and services on a voluntary basis. A number of Blue Angel criteria are for products with low emissions to indoor air and thus potential impact on human health including: RAL-UZ 38 for furniture and slatted frames and RAL-UZ 117 for upholstered furniture.

- **ÖSTERREICHISCHE UMWELTZEICHEN**[55]**:** The Austrian Ecolabel addresses itself primarily to consumers but also to manufacturers and public procurement. The ecolabel provides consumers with guidance in order to choose products or services with least hazardous to the environment or health. The ecolabel draws the consumers' attention to aspects of environment, health and quality (fitness for use).

Apart from the ecolabels for furniture, other ecolabels for certain materials used in furniture also exist. The main ones are:

- **Textiles and leather**: The main ecolabels and standards are the European Ecolabel, Nordic Swan and Ökotex standard 100.
- **Matresses and foams**: The main ecolabels and standards are the European Ecolabel and the PU-foam SHE-standard (CertiPUR). The Blue Angel for upholstered furniture also contains criteria for padding materials.

2.3.1. Comparison of the scope and specifications established for the most recognized European Ecolabels

A comparison of the scope established for the most recognized European ecolabels are given in Table 2 below.

Table 2. Comparison of the scope established for the most recognized European ecolabels

ECOLABEL NAME	LOGO	SCOPE	CONDITIONS TO BE FULFILLED
EUROPEAN ECOLABEL FOR WOODEN FURNITURE		Free-standing or built-in units used for storing, hanging, lying, sitting, working and eating of **domestic furniture** (**indoor and outdoor use**) or **business purposes** (**office, school, restaurants and hotels**) (**indoor use**).	- The product shall be made of at least **90 % w/w** solid wood or wood-based materials. Glass, if easily replaceable may be excluded from the weight calculation as may technical equipment and fittings. - The weight of **any individual material**, other than solid wood and wood-based materials, shall not exceed **3 %** of the total weight of the product. The **total combined weight** of such materials shall not **exceed 10 %** of the total weight of the product.
NORDIC SWAN FOR FURNITURE AND FITMENTS		Furniture, fitments, doors and lamps for indoor use may be Nordic Ecolabelled. **Outside the definition of this product group are**: Building products (e.g. walls, stairs, mouldings, plates and boardsplate materials), sanitary equipment, carpets, textiles, office equipment and other products that primary have another function than a piece of furniture, as well as furniture for outdoor use.	- The whole product shall be approved, for example a bed may only be marketed as ecolabelled, if both the mattress and the bed end are approved. - The different materials (wood, wood-base panels, metal, plastic, padding materials, textiles and glass) in the products may be approved on the basis of a specific list of materials. Combination of materials must fulfil the requirements of the criteria and in the case of the individual products, all requirements must be fulfilled.
NORDIC SWAN FOR OUTDOOR FURNITURE AND PLAYGROUND EQUIPMENT		This label applies to **outdoor furniture (garden furniture)** and **play and park equipment** (**domestic use and for public play areas**) **Outdoor furniture includes** : • tables; • Movable chairs; • armchairs; • benches; • sofas.	The different materials in the products may be approved on the basis of a specific list of materials.

ECOLABEL NAME	LOGO	SCOPE	CONDITIONS TO BE FULFILLED
		Playground equipment includes: • swings; • slides; • play houses; • Other outdoor equipment for play. **Park equipment includes**: • railing/fences; • window boxes; • flag poles; **Refuse baskets and outdoor furniture left outdoors on a permanent basis.** **This product group does not include:** •Outdoor furniture featuring padding or textiles •Swing seats •Hammocks •Safety surfaces for playground equipment, cycles or toys for outdoor use.	
NORDIC SWAN FOR PANELS FOR THE BUILDING, DECORATION AND FURNITURE INDUSTRIES		Products that can be labelled include: -**Wood-based panels made up of a least 85% wood** in terms of weight, with or without laminate finishes -Plasterboards -Mineral-based acoustic panels -Solid wood (with finish) that has been assembled in panel form (for instance, by the consumer) Materials for panels for both indoor and outdoor use can carry the Nordic Ecolabel. Uses for the panels can be found in interior lining of ceilings, walls and floors, in the exterior wind-proofing of walls and ceilings and in the manufacture of furniture and fittings, such as desks, cabinets, etc. The criteria do not pertain to metal panels or facing panels and panels that are used primarily to insulate against heat/cold loss, irrespective of the materials used in these panels. Neither do the criteria pertain to pure HPL (High Pressure Laminate) panels nor to plastics-based panels, such as those used in bathrooms.	The different materials (**wood, bamboo and willow, paper and cardboard and minerals**) in the products may be approved on the basis of a specific list of materials.

ECOLABEL NAME	LOGO	SCOPE	CONDITIONS TO BE FULFILLED
		Ordinary untreated planed and unplaned wood panels are not eligible to carry the Nordic Ecolabel.	
BLUE ANGEL FOR WOOD PRODUCTS AND WOOD-BASED PRODUCTS (RAL-UZ 38)		The German "**Blauer Engel**" does not have an eco-label for furniture in general, but it does have a label **for objects made out of wood and/or wood-based material** (**RAL-UZ 38**). The label applies to **ready-to-use final products for indoor use** (e.g. furniture, interior doors, panels, floorings with painted surfaces, laminate floorings, prefabricated parquet/linoleum) **which are made for more than 50%, from wood and/or wood-based materials** (chipboards, coreboards, fibreboards, veneer panels, each non-coated or coated). **This product group does not include:** •Window frames •Semifinished products.	Despite this relatively low percentage requirement leaving space for other materials, this label does not include any requirement for non wood materials. This means that it appears as a label of wood in furniture rather than of furniture made from wood-based materials.
BLUE ANGEL FOR UPHOLSTERED FURNITURE (RAL-UZ 117)		The label applies to **ready-to-use indoor upholstered furniture** (**RAL-UZ 117**) according to DIN 68880, which **are not mainly made from wood and/or wood-based materials** (allocated to the **RAL-UZ 38**), **i.e less than 50%.**	The different materials (**e.g leather, textiles, foams**) in the products may be approved on the basis of a specific list of materials.
MILIEUKEUR FOR FURNITURE[56]		Indoor and outdoor furniture. The certification scheme includes the following types of furniture: • chairs (for offices, dining rooms, gardens and cantine), seats, sofa's and stools; • tables and desks; • cupboards, shelves, worktops; • kitchens (excl. equipment and accessories); • beds, bedsteads and cradles (excluding mattresses); • bathroom furniture. Excluded are: • medical furniture, like dentist's chairs and wheelchairs; • chairs connected to the surroundings, like street furniture, train-seats and cinema-seats.	In order to be eligible for the eco-label, furniture must consist of one or more of the materials mentioned in the scheme. The list contains a broad range of materials, i.e.: • ligneous materials, such as solid wood, cane, bamboo, chipboard, plywood, MDF, softboard, hardboard, paper; • metals, such as iron and steel, stainless steel, aluminium; • plastics, such as polyolefin, acrylic polymers, polystyrene and ABS, polyurethane, polyester, polyamide, polycarbonates; • rubbers, NR, NBR, SBR, EPM/EPDM • resin and synthetic resin such as bakelite, melamine resin, urea resin, epoxy resin, alkyd resins; • wool, cotton and other natural fibres

ECOLABEL NAME	LOGO	SCOPE	CONDITIONS TO BE FULFILLED
			• leather. Combined materials (like boards made of plastic/wood fibre) are included provided that the separate components comply with the stipulated material criteria (unless the material constitutes less than 5% of the piece of furniture, see below). Composite stone material (plastics/minerals) is also included. In total 95% (w/w) of the material used in a piece of furniture should comply with the criteria. Glass and mirrors can be applied without further requirements. Materials that make out a small percentage (to a maximum of 5% (w/w)) of the total weight of the furniture are exempted from the criteria. These materials need to be specified. The use of adhesives and coatings falls outside the 5% (m/m) exception rule. Lead should not be applied (lead materials do not fall within the exemption rule). For all materials for which no material requirements are drawn up, these materials may contain no cadmium or mercury compounds.
ÖKOCONTROL FOR FURNITURE		Applies to furniture made of **massive wood**, including chipboard and triplex boards, block boards, laminate consisting of a number of veneering, back walls and bottoms of drawers consisting of triplex furniture containing padding.	-
ÖSTERREICHISCHE UMWELTZEICHEN FOR WOODEN FURNITURE (UZ06)		The following types of furniture are covered: - Furniture for the living area: for sleeping and living rooms, teenagers 'and children´s rooms, antechambers and wardrobes, kitchens and bathrooms. - Office furniture - Furniture for public buildings: for schools, nurseries and kindergartens,	The main material of which furniture carrying the Austrian Eco-label shall be made is wood. The following wood-based panels specified in ÖNORM EN 13986 may be used for eco-labelled furniture:

ECOLABEL NAME	LOGO	SCOPE	CONDITIONS TO BE FULFILLED
		hospitals and sanatoriums, laboratories, workshops, commercial premises (shopfittings), restaurants, hotels and boarding houses, boarding schools and homes, barracks, function halls, theatres, cultural and sacred buildings, libraries, bathing and sports facilities and meeting rooms. This product does not include: - Outdoor furniture - Upholstered furniture (UZ54) - Office chairs (UZ34)	➢ Solid wood panels ➢ Plywood ➢ Oriented strand boards (OSB) ➢ Resin-bonded particleboard ➢ Fibreboards For surface treatment stains, oils and waxes, varnishes and glazes are permitted. Furthermore, also coatings with non-halogenated plastic, non-halogenated plastic lamination or edge protection are permitted. The following non-wood materials can be part of the furniture: ➢ Metals – also with chromium plated or anodised surface ➢ Glass ➢ Natural stone slabs ➢ Resin-bonded mineral panels Leather provided compliance with the criteria ➢ Textiles provided compliance with the criteria ➢ HPL boards (high-pressure laminate boards) ➢ The use of plastic components shall be explained and limited to a minimum which is functionally necessary (e.g. slide bearings). The use of halogenated synthetics is prohibited.
ÖSTERREICHISCHE		Desk-chairs and swivel-chairs	-

ECOLABEL NAME	LOGO	SCOPE	CONDITIONS TO BE FULFILLED
UMWELTZEICHEN FOR OFFICE CHAIRS (UZ34)			
ÖSTERREICHISCHE UMWELTZEICHEN FOR UPHOLSTERED FURNITURE (UZ54)		Upholstered furniture according to DIN 68880 and ÖNORM A 1681-2, which is not predominantly, i.e. more than 50 vol- %, of wood and/or wood –based materials (particleboards, blockboards, fiberboards, veneer sheets, each uncoated or coated).	-
NF-ENVIRONNEMENT MARK FOR FURNITURE (NF 217)		Furniture products for domestic and professional use	-

Table 3 summarises the specifications of the most recognized European ecolabels for the main materials or characteristics:

Table 3. Main environmental criteria covered by several European ecolabels

	Stichting Milieukeur	NF Environnement Mark (NF217)	Öko Control	Nordic Swan (furniture and fitments)	Blue Angel RAL-UZ 38	Österreichische Umweltzeichen UZ 06 UZ 34
Wood						
Forestry	x	x	x	x	x	x
Use of hazardous substances	x			x		x
Heavy metals in coatings	x	x	x	x	x	x
Coating	x		x	x	x	x
VOC emissions by coating	x	x		x	x	x
Formaldehyde emissions	x	x	x	x	x	x
Metals						
Raw material	x					x
Recycled material	x			x		x
Galvanic processing	x	x				
VOC emissions by coating	x	x		x		x
Coating process	x		x	x		
Heavy metals in coating	x	x	x	x		x
Plastics						
Material choice	x		x			x
CFCs	x	x		x		x
Certain flame retardants	x			x		
Heavy metals	x			x		x
Marking	x	x		x		x
Recycling	x			x		
Textiles						
Toxic compounds	x		x	x		

	Stichting Milieukeur	NF Environnement Mark (NF217)	Öko Control	Nordic Swan (furniture and fitments)	Blue Angel RAL-UZ 38	Österreichische Umweltzeichen UZ 06 UZ 34
Chlorinated fibres	x			x		x
Certain halogen. flame retardants	x		x	x		x
Certain pigments	x		x	x		x
Heavy metals		x	x	x		x
VOC, formaldehyde emiss.	x					
Leather						
Chromium	x			x		x
Azo-dyes	x			x		x
Heavy metals	x			x		x
Glass						
Limitation of certain types				x		
Replaceability				x		
Stone (like) materials						
Winning	x					
Heavy metals	x					
Glues and adhesives						
VOC emissions	x			x		x
Energy use						
Max. energy defined		x		x		
Functional aspects						
Quality				x		x
Health and safety			x	x		x
Reparability, durability	x		x	x		x
(Artificial) leather quality	x					
Textile quality	x			x		

	Stichting Milieukeur	NF Environnement Mark (NF217)	Öko Control	Nordic Swan (furniture and fitments)	Blue Angel RAL-UZ 38	Österreichische Umweltzeichen UZ 06 UZ 34
Packaging materials	x			x	x	x
Tack-back guarantee						x
Waste at production sites				x		x
Maintenance	x					

Source: GPP Training Toolkit Background product report

This table shows that the proposed revision of EU Ecolabel criteria[5] covers the main environmental impacts of the various materials addressed in the different ecolabels.

2.3.2.Number of ecolabelled products established for the most recognized European Ecolabels

Table 4 displays the most recognized European Ecolabels along with the number of ecolabelled products and companies certified:

Table 4. Number of ecolabelled products and companies certified for the most recognized European ecolabels

Ecolabel NAME	Number of COMPANIES CERTIFIED	LICENSES	NUMBER OF ECOLABELLED PRODUCTS
EUROPEAN ECOLABEL FOR WOODEN FURNITURE	1	1	1
NORDIC SWAN FOR FURNITURE AND FITMENTS			> 357
NORDIC SWAN FOR OUTDOOR FURNITURE AND PLAYGROUND EQUIPMENT			
NORDIC SWAN FOR PANELS FOR THE BUILDING, DECORATION AND FURNITURE INDUSTRIES			
BLUE ANGEL FOR WOOD PRODUCTS WOOD BASED PRODUCTS (RAL-UZ 38)	76	177	floor coverings madde of wood (103)
			furniture (49)
			furniture for children (10)
			Indoor doors (5)
			laminate flooring (59)
			lath frames (3)
			lath frames (7)
			living furniture (25)
			office furniture (24)
			Panels of wood (9)
			TOTAL: 294
BLUE ANGEL FOR UPHOLSTERED FURNITURE (RAL-UZ 117)	7	29	low-emission upholstery (28)
			office chairs upholstered (18)
			seats upholstered (25)

[5] For more information see details in "Draft criteria", available online at the project's website: http://susproc.jrc.ec.europa.eu/furniture/whatsnew.html

Ecolabel NAME	Number of COMPANIES CERTIFIED	LICENSES	NUMBER OF ECOLABELLED PRODUCTS
			upholstery (22)
			TOTAL: 93
MILIEUKEUR FOR FURNITURE	2	2	2
ÖSTERREICHISCHE UMWELTZEICHEN FOR WOODEN FURNITURE (UZ06) ÖSTERREICHISCHE UMWELTZEICHEN FOR OFFICE CHAIRS (UZ34)	6	6	≥ 46
NF-ENVIRONNEMENT MARK (NF217)	52	tbd	tbd

3. MARKET ANALYSIS

3.1. Objective

The objective of this report is to characterize the relevant European furniture market and its tendencies at a quantitative and qualitative level. This study is aimed to provide the market knowledge needed for the revision process of the existing EU Ecolabel and Green Public Procurement (GPP) criteria set for the product group under study.

3.2. World furniture overview

World production of furniture is worth about US$422 billion[57]. About US$134 billion of the furniture production comes from the seven high income countries, such as: United States, Italy, Germany, Japan, France, Canada and the United Kingdom. All high income countries combined are responsible for 45% of the world furniture production. On the other hand, more than half (55%) of the world furniture production takes place in middle and low income countries, and it is raising fast due to the enlargement of factory capacities and improvements in logistics and infrastructure. China remains the main leading producer.

The EU-27 furniture production covers over 20% of the world total, having overtaken the NAFTA zone (United States, Canada and Mexico).

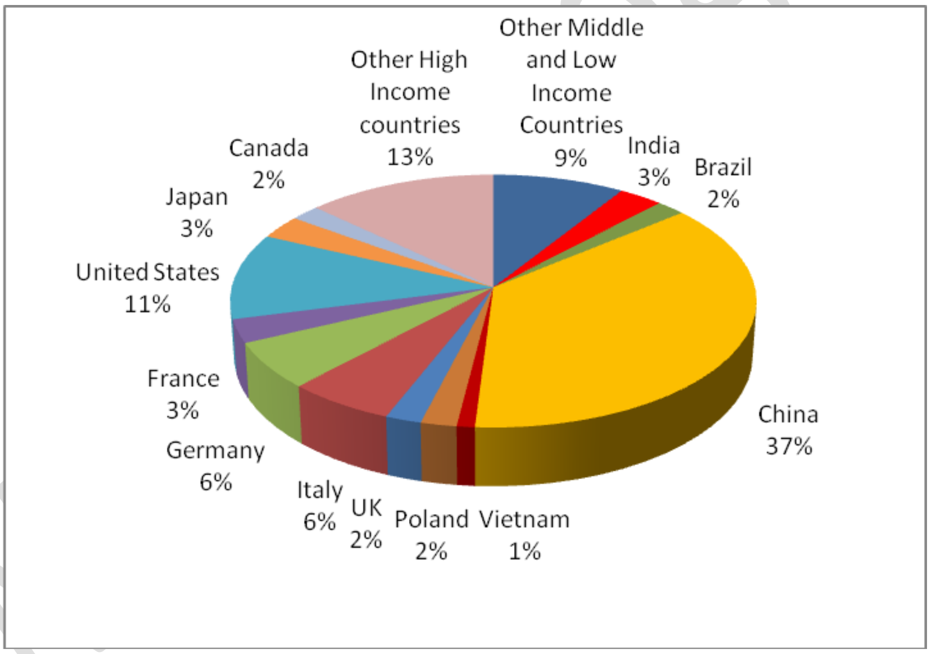

Figure 1. Percentage of world furniture production (2010)

Source: World Furniture Outlook by CSIL

As figure 2 shows, the leading furniture importers are the United States, Germany, France, the UK and Canada. These five countries accounted for combined imports of 46% of the world total. In the 2002-2007 period, a very large increase in the world imports was produced, especially in the United States (from US$17 billion[58] to US$26 billion) and in the United Kingdom (from US$4.3 billion to US$8.6 billion). In 2009, an important decrease in furniture imports was produced over the world due to the recession period reflecting a decrease in consumer goods. In 2008 and 2009, the ratio between imports and consumption decreased as a consequence of the economic situation, and now has stabilized at a level a little below 30%[59]. In the United States, the recession caused a decrease from US$26 billion in 2007 to about US$19 billion in 2009. Growth of imports recovered in 2010 and 2011, reaching US$23 billion in 2011. Emerging countries have very low values of imports[3]: 6% in

India, 5% in Brazil and only 2% in China. In Europe, Germany (10,6%), France (6,9%) and the UK (4,7%) are the main importers of furniture products.

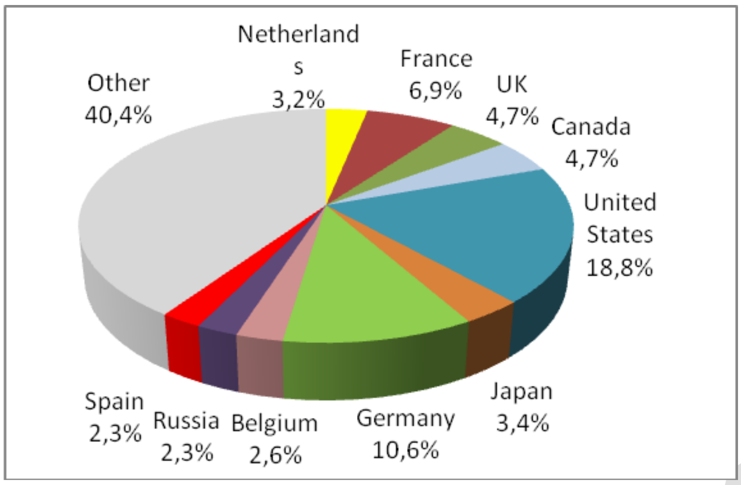

Figure 2. Main world furniture importers (2011)

Source: ICEX Spanish Institute for Foreign Trade

The top five exporters are China, Germany, Italy, the United States and Poland. As figure 3 shows, China is by far the biggest market, with exports just below $38 billion[60] in 2011. World trade of furniture, defined as the average between total exports and total imports, amounted to US$95 billion in 2009 and grew to US$106 billion in 2010, and US$116 billion[2] in 2011.

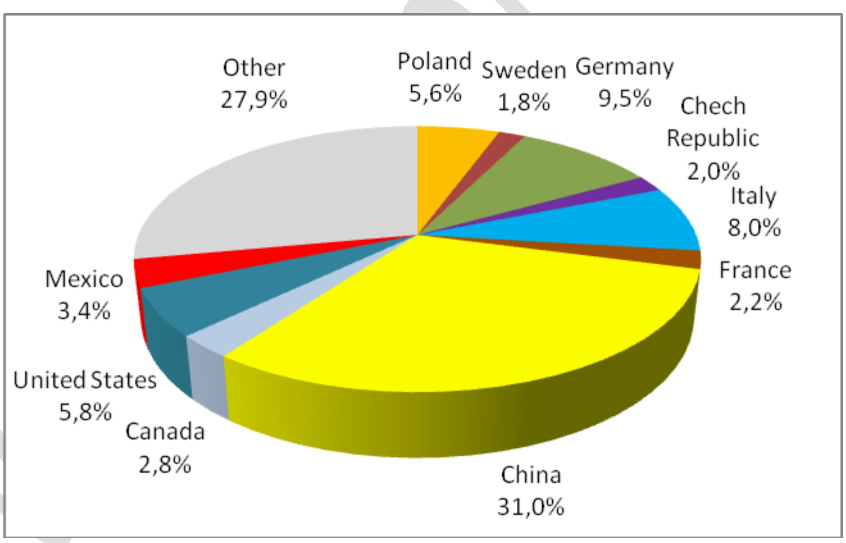

Figure 3. Main world furniture exporters (2011)

Source: ICEX Spanish Institute for Foreign Trade

World trade of furniture is large, and represents about 1% of total world trade of manufactures. It increased quickly until 2008, reaching US$ 117 billion, and decreased by 19% in 2009. Nowadays, international trade has recovered to the pre-recession level and the expected growth by 2013 is about 4%. In 2013, Asia and South America will be the regions with the highest growth of furniture demand, North America will experience a modest growth, while in Europe the stagnation will continue with the exception of Eastern Europe. New opportunities will appear for furniture exporters due to an increasing demand in emerging countries.

3.3. European furniture market and trade

This section analyzes the economic data regarding the product group under study. The scope of analysis includes the EU 27 countries, taking as reference period the last two years with available data (generally 2009-2010 or 2010-2011). All data presented have been extracted from the Eurostat Database and the Market Access Database. The main indicators discussed in this section are related to the production and trade of these products in the EU 27 and in single Member States.

According to NACE the statistical classification of economic activities in the European Community (NACE) furniture products are included in the activity code 310. This division includes the manufacture of furniture and related products of any material except stone, concrete and ceramic. In order to reflect specific product categories covered by this analysis, the following product classifications have been selected[61]:

Table 5. PRODCOM classification for furniture products to be studied

PRODCOM Code	Description
31001150	Swivel seats with variable height adjustments (excl. medical, surgical, dental or veterinary, and barbers' chairs)
31001170	Upholstered seats with metal frames (excluding swivel seats, medical, surgical, dental or veterinary seats, barbers' or similar chairs, for motor vehicles, for aircraft)
31001190	Non-upholstered seats with metal frames (excluding medical, surgical, dental or veterinary seats, barbers' or similar chairs, swivel seats)
31001210	Seats convertible into beds (excluding garden seats or camping equipment)
31001230	Seats of cane, osier, bamboo or similar materials
31001250	Upholstered seats with wooden frames (including three piece suites) (excluding swivel seats)
31001290	Non-upholstered seats with wooden frames (excluding swivel seats)
31001300	Other seats, of HS 94.01, n.e.c.
31011100	Metal furniture for offices
31011200	Wooden furniture of a kind used in offices
31011300	Wooden furniture for shops
31021000	Kitchen furniture
31031100	Mattress supports (including wooden or metal frames fitted with springs or steel wire mesh, upholstered mattress bases, with wooden slats, divans)
31091100	Metal furniture (excluding office, medical, surgical, dental or veterinary furniture; barbers' chairs - cases and cabinets specially designed for hi-fi systems, videos or televisions)
31091230	Wooden bedroom furniture (excluding builders' fittings for cupboards to be built into walls, mattress supports, lamps and lighting fittings, floor standing mirrors, seats)
31091250	Wooden furniture for the dining-room and living-room (excluding floor standing mirrors, seats)
31091300	Other wooden furniture (excluding bedroom, dining-, living-room, kitchen office, shop, medical, surgical, dental/veterinary furniture, cases and cabinets designed for hi-fi, videos and televisions)
31091430	Furniture of plastics (excluding medical, surgical, dental or veterinary furniture -

	cases and cabinets specially designed for hi-fi systems, videos and televisions)
31091450	Furniture of materials other than metal, wood or plastic (excluding seats, cases and cabinets specially designed for hi-fi systems, videos and televisions)

Source: Eurostat. PRODCOM

- The Market Access Database is an important operational tool of the European Union's Market Access Strategy which has been used to provide an overview of trade flows for furniture (imports and exports) between EU-27 and non-EU countries. This database classifies furniture products with different codes of NACE. The products that have been included to analyze the trade flows belong to the code numbers 9401 "*seats*" and 9403 "*other furniture and parts thereof*".
- Table 6 gives a systematic overview of HS Code 9403, including its sub-categories and detailing the kind of products. Medical, surgical, dental and veterinary furniture, as well as barber's chairs and similar chairs have been excluded from the scope of the project, because the project is focused on the types of furniture with the highest market shares (e.g. furniture for dining rooms, living rooms and bedrooms, kitchens, seats, office furniture).

Table 6. Other furniture products and parts thereof classified in code 9403

CN Code	Description
9403.10	Metal furniture of a kind used in offices
9403.20	Other metal furniture
9403.30	Wooden furniture of a kind used in offices
9403.40	Wooden furniture of a kind used in the kitchen
9403.50	Wooden furniture of a kind used in the bedroom
9403.60	Other wooden furniture
9403.60.10	Wooden furniture of a kind used in the dining room and the living room
9403.60.30	Wooden furniture of a kind used in shops
9403.60.90	Other wooden furniture
9403.70	Furniture of plastics
9403.80	Furniture of other materials, including cane, osier, bamboo or similar materials

Source: Market Access Database

3.3.1. EU furniture production

In accordance with the information from Eurostat database, European furniture production experienced substantial growth over 9% from 2003 to 2007. After that period, between 2007 and 2009, the production decreased by 22% in the EU-27 due to the economic recession. From 2009 to 2011 the production recovered to certain extent with a growth rate of nearly 7%, and the production value below € 60.000 millions in 2011.

Figure 4. Evolution of the furniture production value in the EU 27 from 2003 to 2011

Source: Eurostat. PRODCOM

There are many ways in which furniture market can be segmented. In this report three basic types of segmentation have been considered:

- Segmentation by geographical area
- Segmentation by materials
- Segmentation by type of furniture

3.3.1.1. EU Furniture production by geographical area

After Asia Pacific countries, which represent over 40% of world furniture consumption and around 50% of world furniture production, Western Europe is the main furniture manufacturing region, accounting for around 20% of the global furniture consumption and over 20%[62] of entire furniture production. During the recession period, a change in patterns has been observed in the Western Europe, having now the second position among world's major producing areas. In 2002 it was the first producing area with about 33% of the world furniture production.

According to CSIL[63] forecasts, the Western European furniture market was expected to decrease by 1% in 2012 and to remain stable in 2013. It is expected that Scandinavian countries will have a higher growth rate than other countries. Central European countries and the United Kingdom will remain stable, while southern countries will further slowdown.

One of the indicators analysed is the volume of Communitarian production. PRODVAL indicator has been analyzed in order to assess the economic significance of production in the EU-27 countries. PRODVAL data is expressed in terms of monetary value (million Euros).

The leading producer countries are Italy and Germany with production values over € 10000 million. United Kingdom, France, Poland and Spain have also important production values exceeding € 3250 million.

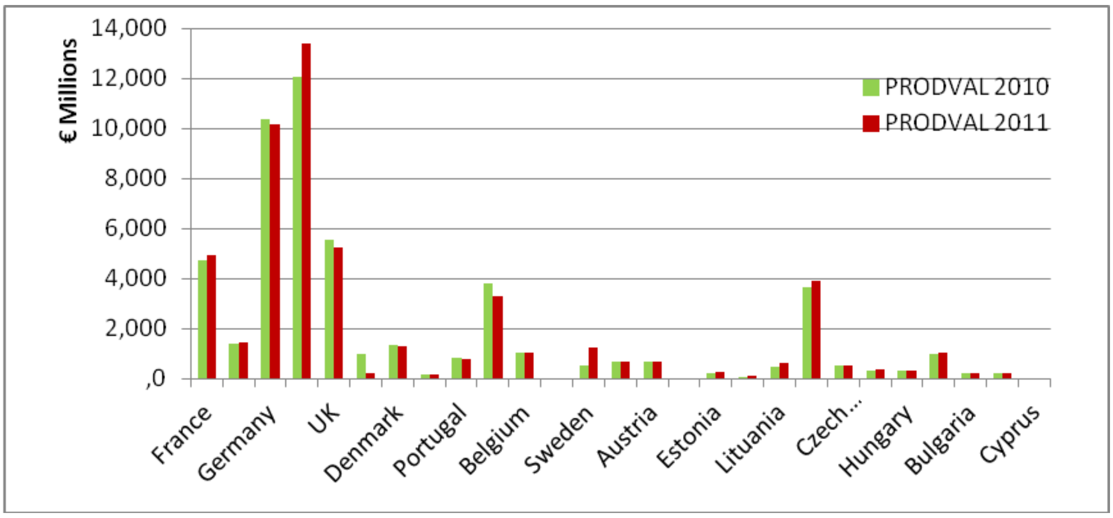

Figure 5. Production value of furniture in the EU-27 countries (2010-2011)

Source: Eurostat. PRODCOM

PRODQNT indicator has been used to determine the furniture production in terms of the quantity produced. PRODQNT data is expressed in terms of number of items produced (p/st), except for metal furniture, classified as NACE code 31091100, which is expressed in kilograms.

Figure 6sho the number of furniture units produced in 2010 and 2011 out of all the products covered by codes given in Table 5.

Although Italy recorded a negative performance in the last decade (see Figure 7), it is still a key player in the furniture sector, as it is the third largest producer in the world, after China and the United States. Italy's production amounts around 160 millions units of furniture, followed by Germany (over 80 millions), Poland (55 millions), UK (49 millions), France (35 millions) and Spain (35 millions). From the period 2010-2011, Eastern European countries recorded the highest furniture production growth rate: 25% in Estonia, 24% in Lithuania, 12% in Poland and nearby 2% in Hungary. On the other side, southern countries' furniture production further decreased in 2011, with Spain and Greece having negative rates of around -11% and -18%, respectively[64]. According CSIL, Western European furniture production experienced a slight increase of 1,3% in 2011, being Germany and Sweden the countries which better reacted to the crisis in terms of production growth rates[65].

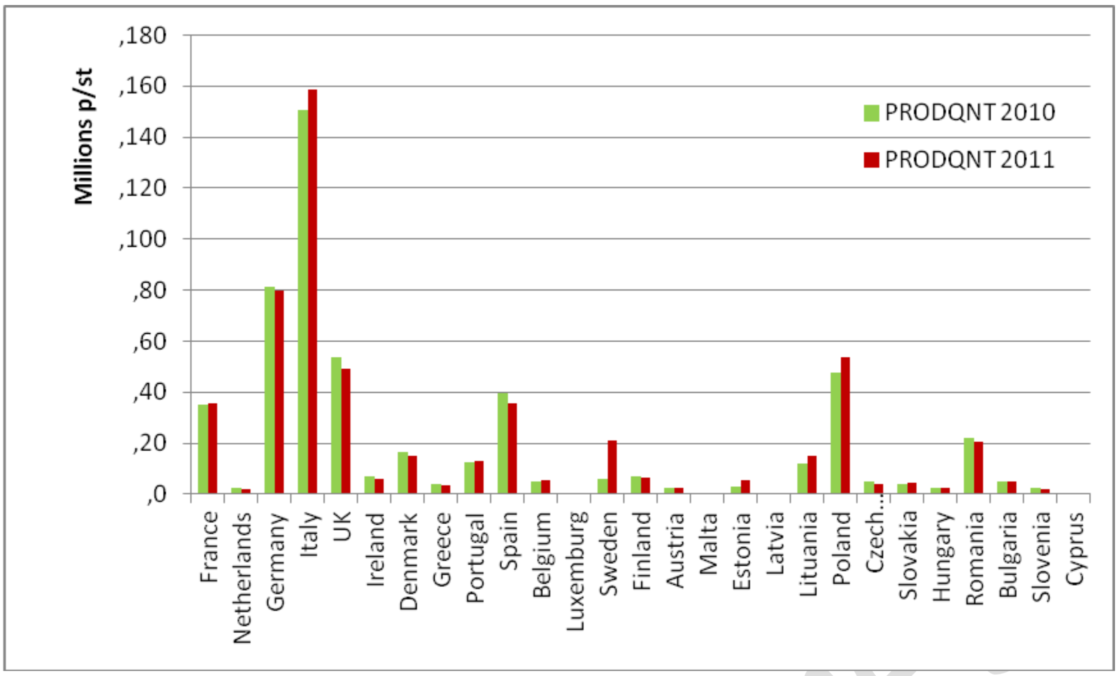

Figure 6. Number of furniture products6 produced in the EU-27 countries (2010-2011)

Source: Eurostat. PRODCOM

Evolution of the furniture production in the top six EU manufacturing countries in the period 2003-2011 is presented in the below figure:

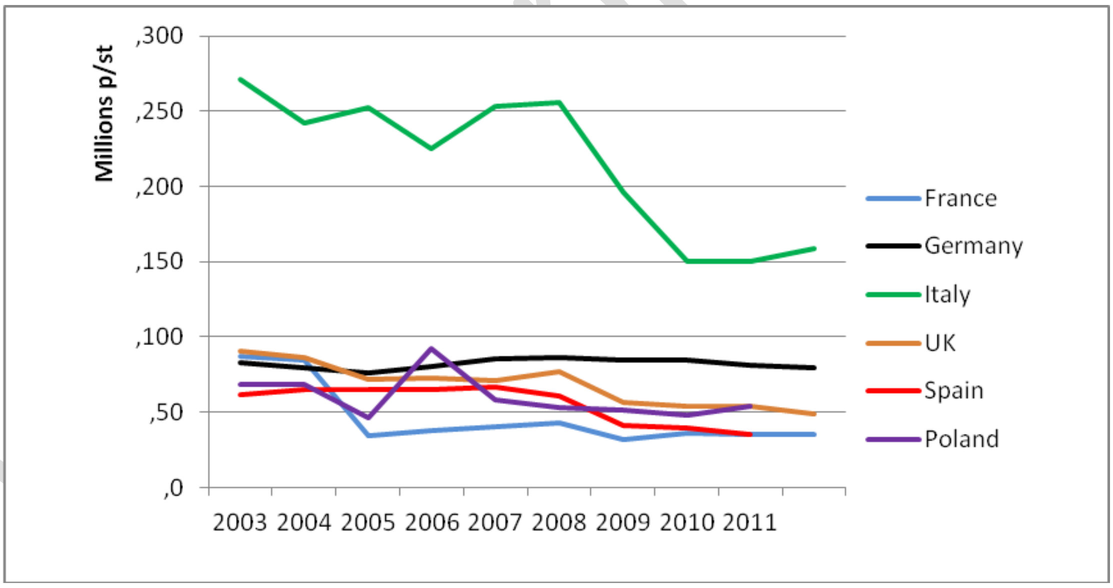

Figure 7. Evolution of the furniture production7 in the top 6 EU manufacturing countries (2003-2011)

Source: Eurostat. PRODCOM

The quantity of metal furniture produced in kg (e.g. metal beFigure 8. There are no data available for Netherlands, Germany, Sweden and Latvia. There are no production in Luxembourg, Malta and Cyprus.

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[6] excluding metal furniture other than office, medical, surgical, dental or veterinary furniture; barbers' chairs - cases and cabinets specially designed for hi-fi systems, videos or televisions

[7] excluding metal furniture other than office, medical, surgical, dental or veterinary furniture; barbers' chairs - cases and cabinets specially designed for hi-fi systems, videos or televisions

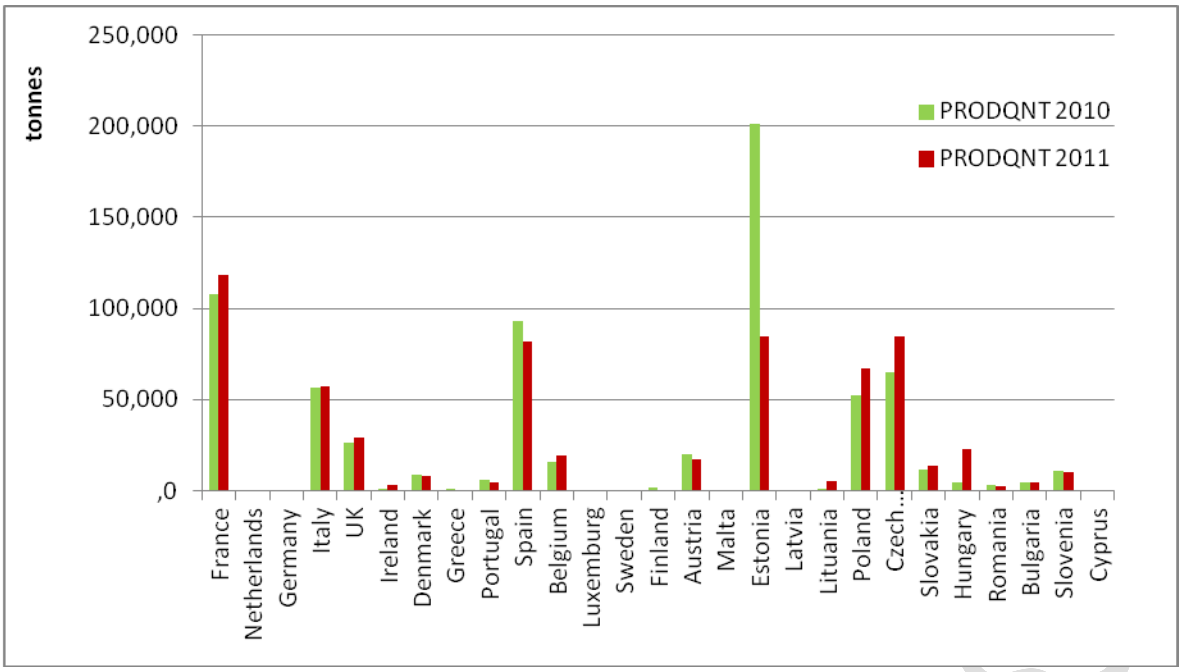


Figure 8. Production of metal furniture[8] in the EU-27 countries, (2010-2011)

Source: Eurostat. PRODCOM

3.3.1.2. EU furniture production by materials

The EU furniture industry uses various raw materials to manufacture different types of furniture, such as tables, chairs, sofas, kitchens, wardrobes, support mattresses, etc. The most relevant materials for the production of furniture are:

Wood: solid wood and wood based products such as panels are widely used in furniture production. Tables, desks and cupboards are the typical products where wood panels are used. Particleboard, fibreboard and plywood are the three main categories of wooden panels, which are produced under heat and pressure with the addition of an adhesive to particles, glue fibres or sheets of wood respectively.

Metal: aluminium, steel and iron are the main types of metals used in furniture products. Most of them are used as a base material, for example in cupboards, tables and chair legs. Steel and iron are used in many products, ranging from office furnishings to outdoor settings. For example, the properties that offer cast iron (hardness, heaviness and general tough composition) are adequate for outdoor use, and this material is common used for bench legs and solid iron tables. Stainless steel is used widely for modern interior furnishings, such as chairs legs, supports and body pieces, slides and hinges. It is especially suited for chair legs, supports and body pieces due to its high tensile strength, allowing it to be applied using hollow tubes and reducing weight. Aluminium furniture has great advantages as it does not rust, is tough, light and durable. This material is used extensively for stamped and cast furniture, especially in molded chairs. Other applications are tables, dining tables, sofas, etc. Other metals are also used in fittings, like zinc, nickel or chrome.

Plastic: thermoplastics and thermosetting polymers are used in the furniture sector. Thermosetting polymers provide stronger structure for furniture components, being more durable than thermoplastics. Polystyrene (PS) and polyvinyl chloride (PVC) are common types of thermoplastics used in tables and plastic lawn furniture. Another thermoplastic used is polypropylene (PP) which can withstand movement, and for this reason is an appropriate material for hinges. On the other hand, thermosets are generally used as padding materials, polyurethane foams are used in upholstered furniture as a filling material for sofas, seats, back of seats, arm rests, etc, and phenolics are used as a furniture adhesive.

[8] excluding office, medical, surgical, dental or veterinary furniture; barbers' chairs - cases and cabinets specially designed for hi-fi systems, videos or televisions

Other materials used in furniture industry include glass, stone, upholstery made of leather, cane, bamboo, rattan, etc.

Information regarding furniture production in 2011 in the EU-27 is provided in Table 7. Both quantity (millions p/st) and value (millions €) of the main materials used for furniture is reported. Production and market value of pieces of furniture based on different materials is presented in Figure 9 and in Figure 10.

Table 7. Furniture production in the EU-27 classified by materials (2011)

Product	Furniture production	
	Quantity (M p/st)	Value (M €)
Wooden furniture	378	32392
Metal furniture	>77	9660
Furniture of plastics	38	442
Furniture of materials other than metal, wood or plastic	9	290
Not specified	168	15185

Source: Eurostat. PRODCOM

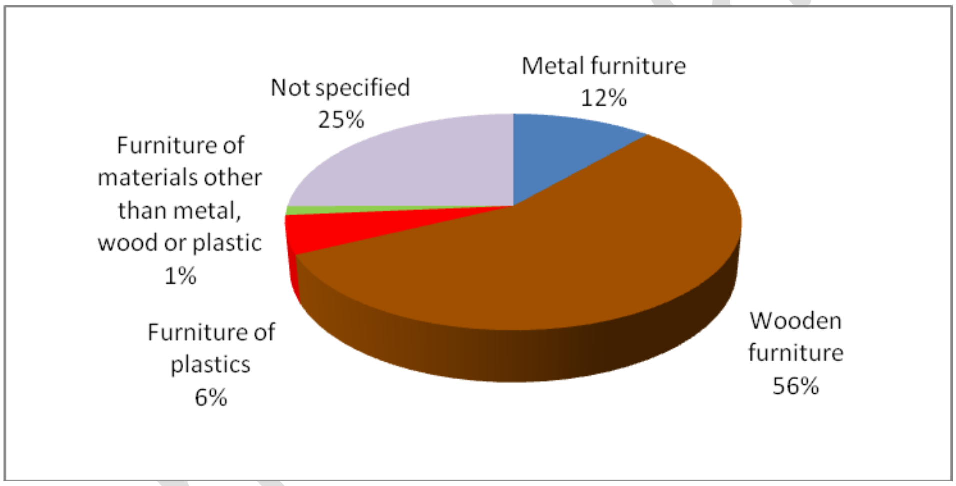


Figure 9. Furniture production in the EU-27 classified by materials (2011)

Source: Eurostat. PRODCOM

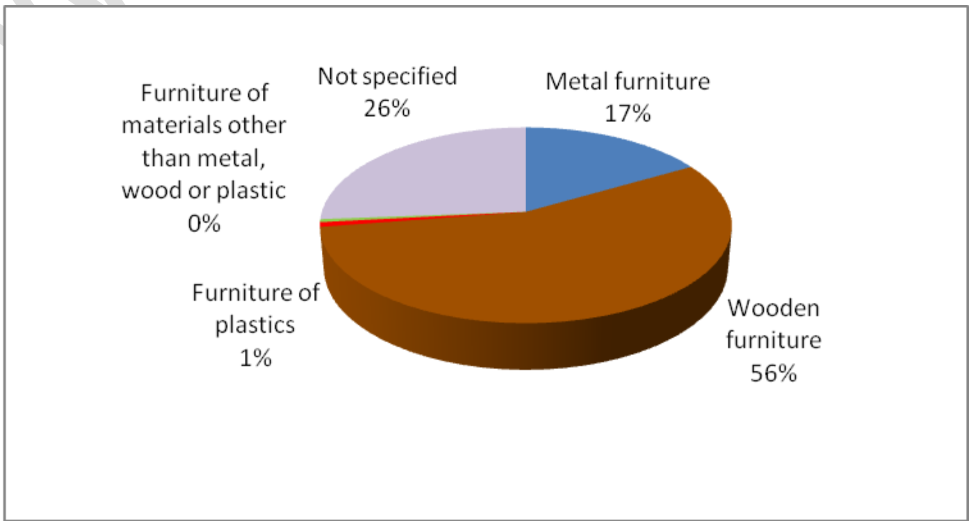


Figure 10. Market value of EU-27 furniture by materials (2011)

Source: Eurostat. PRODCOM

The most common material used for furniture is wood (56% of the pieces of furniture produced in the EU 27 in 2011 are based on wood, which represent 56% of the production value). Metal is the second material most commonly used in furniture industry (12% of items produced and 17% of the production value), followed by plastic (6% of items produced and 1% of the production value) and other materials (1% of items produced and negligible production value) like bamboo, cannier, osier, etc. There is a lack of quantitative data about the materials used for kitchen furniture, mattress supports and some kind of seats. This unknown information refers to 25% of the total number of items produced or, in other terms, to 26% of the production value. However, it is expected that these 25% also contains wooden, metal, plastic and other materials.

3.3.1.3. EU furniture production by type

Classifying furniture in accordance with the type (application) of the furniture is one of the most commonly used methods for market segmentation. There are a wide variety of types of furniture available on the market, with different styles and different functions. According to data obtained from Eurostat, the types of furniture considered for the market segmentation are the following: upholstered seats, non-upholstered seats, office furniture, furniture for shops, kitchen furniture, mattress supports, bedroom furniture, dining-room and living-room furniture, and finally other type of furniture. Some examples of the types of furniture included in each category are listed below:

Upholstered seats: armchairs, reclining chairs, sofas, divans, footstools, seating elements upholstered with leather, wool, synthetic material, cotton, etc.

Non-upholstered seats: seats, armchairs, rocking chairs, seats convertible into beds, stools, etc.

Office furniture: desks, chairs, drawer unit, filing cabinets, integrated workstations, etc.

Furniture for shops: counters, display cases, shelves, etc.

Kitchen furniture: kitchen tables and chairs, fitted cabinets and kitchen units, free-standing pieces such as moveable trolleys and butcher blocks, etc.

Mattress supports

Bedroom furniture: beds, headboards, bedside tables, dressing tables, chests of drawers, wardrobes (fitted or free-standing), etc.

Dining and living room furniture: dining sets (tables and chairs), dressers, coffee tables, sideboards, shelf systems, room dividers, etc.

Other furniture: cupboards, bookcases and wall units, garden chairs and seats, occasional furniture such as desks, small tables, mirrors or hall-stands, bathroom furniture like storage cabinets, baskets, etc.

Quantitative data regarding furniture production by type is reported in Table 8. These pieces of information are even presented in Figure 11. and in with the aim of providing a better overview of the market segmentation in terms of both quantity (millions of items) and value (millions €).

Table 8. Furniture production in the EU-27 classified by type (2011)

Product	Furniture production	
	Quantity (M p/st)	Value (M €)
Upholstered seats	54	8679
Non-upholstered seats	92	4837

Office furniture	63	7198
Furniture for shops	14	3250
Kitchen furniture	104	10595
Mattress supports	19	1214
Wooden bedroom furniture	64	6111
Wooden furniture for the dining-room and living-room	53	5176
Other wooden furniture	160	5200
Not specified	47	5711

Source: Eurostat. PRODCOM

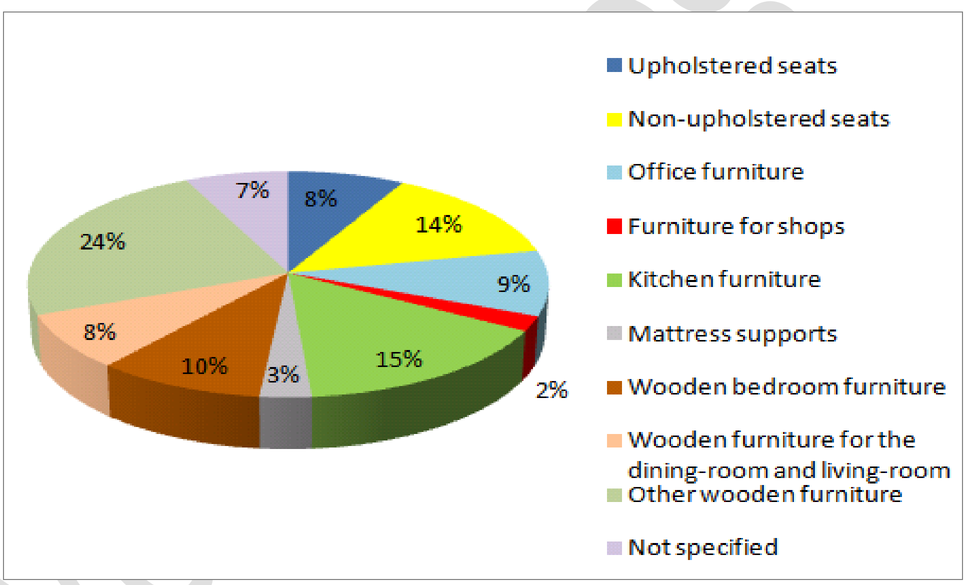


Figure 11. Furniture production in the EU-27 classified by type (2011)

Source: Eurostat. PRODCOM

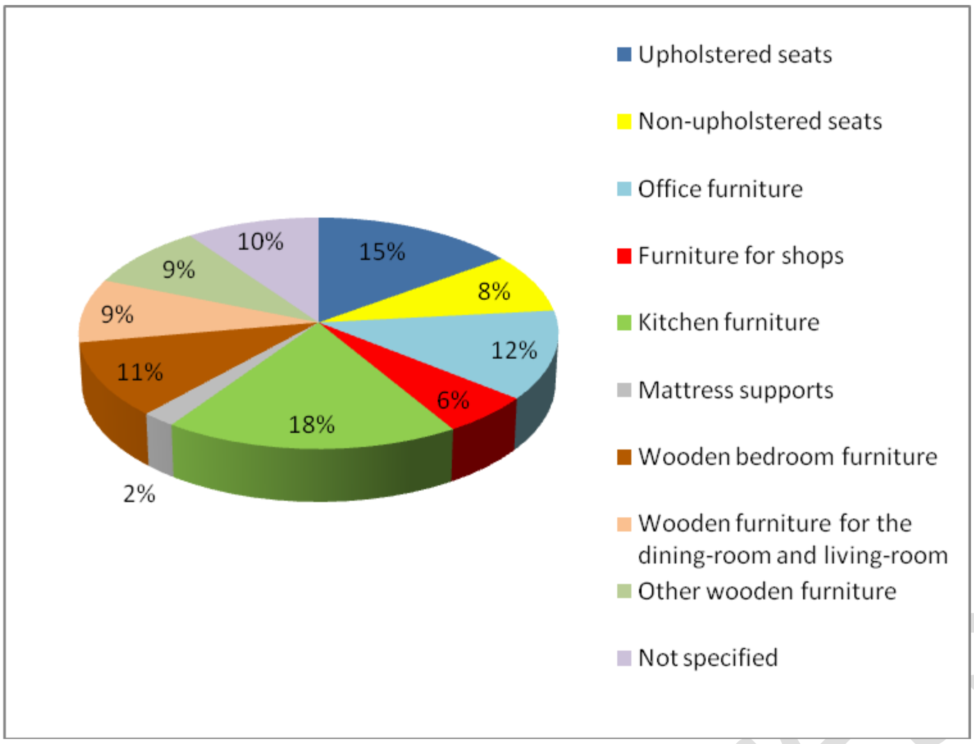


Figure 12. Market value in the EU-27 by type of furniture (2011)

Source: Eurostat. PRODCOM

18% of the pieces of furniture manufactured in 2011 in the EU-27 is composed of wooden furniture used in dining rooms, living rooms and bedrooms (20% by value). Another 24% is represented by unspecified wooden furniture (9% by value). Eurostat does not provide quantitative data about bedroom, dining-room and living room furniture other than wooden. Part of this information is included in the group classified as not specified, which represents about 7% of the total items produces (10% by value). Due to this fact, the shares of bedroom, dining-room and living room furniture are expected to be higher. Other important production subsectors are kitchen furniture (15% by number, 18% by value), non-upholstered seats (14% by number, 8% by value), office furniture (9% by number, 12% by value), upholstered seats (8% by number, 15% by value), mattress supports (7% by number, 10% by value). More than a half of the office furniture produced in Europe is made of wood (60% by number, 69% by value), whereas metal represent 40% by number and 31% by value.

Kitchen furniture has grown in importance due to a general change in consumer behaviour. Kitchen has become one of the most important rooms at home, and nowadays it is not just a place where meals are prepared but also a room for socializing and/or entertainment.

The European production of office furniture[66] increased by 3.3% in 2011, in part due to the positive performance of countries like Germany, Austria and the Nordic countries. On the other hand, the production has fallen in Southern Europe. The restructuring process continued in 2011, with some companies interested by insolvency procedures, factory closures and mergers and acquisitions process. Regarding kitchen furniture[67], Germany was the largest European producer in 2011, accounting for 32% of total European kitchen production, followed by Italy (20%) and the UK (12%). These countries are also in the top three European kitchen consumers' ranking. The European kitchen furniture consumption remained stable in 2011, with a little decrease of 0.1% in 2011.

3.3.2. EU furniture trade: imports and exports

Trade statistics have been taken from Eurostat and Market Access Database (MADB). Not all the transactions are registered in Eurostat, because the statistics are gathered from the customs and EU companies that give them on voluntary basis. MADB provides an overview of trade flows in furniture between the EU countries and the non-EU countries. MADB data have been used to analyze extra-EU trade.

3.3.2.1. Intra and Extra EU-27 furniture trade

Imports:

The total furniture imports by European countries, including intra-EU 27 and extra-EU 27, recorded a significant decline (15%) in the period between 2008 and 2009. However, in 2011 signs of recovering were observed with an increase of around 13% over 2009.

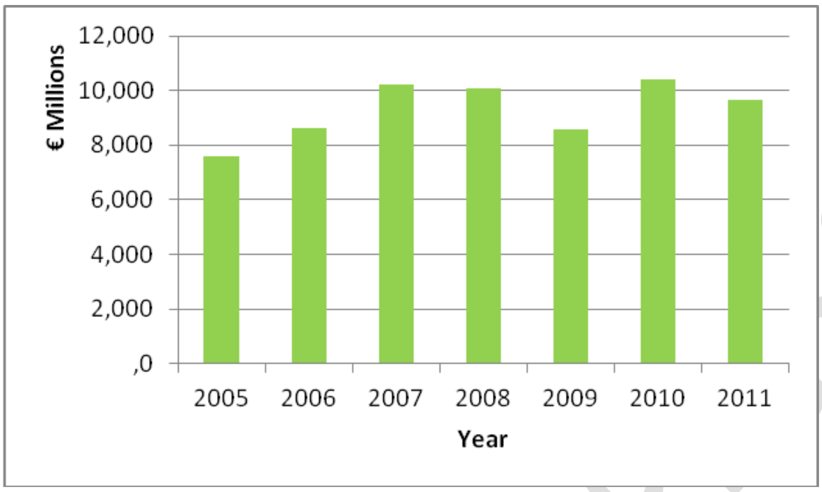


Figure 13. Evolution of furniture imports in the EU-27

Source: Eurostat. PRODCOM

As illustrated in Figure 14, three largest European importers are Germany (about 21% of the total EU 27), France (16%) and the United Kingdom (13%), reaching values over € 3000 million. Following Germany, there is a group formed by Italy, Spain, Austria, Belgium and Netherlands in which each country has imports worth among €1265 to €1900 million.

Although import penetration is increasing, Italy still records the lowest import to consumption ratio of the EU 27 area and one of the lowest at a world level.

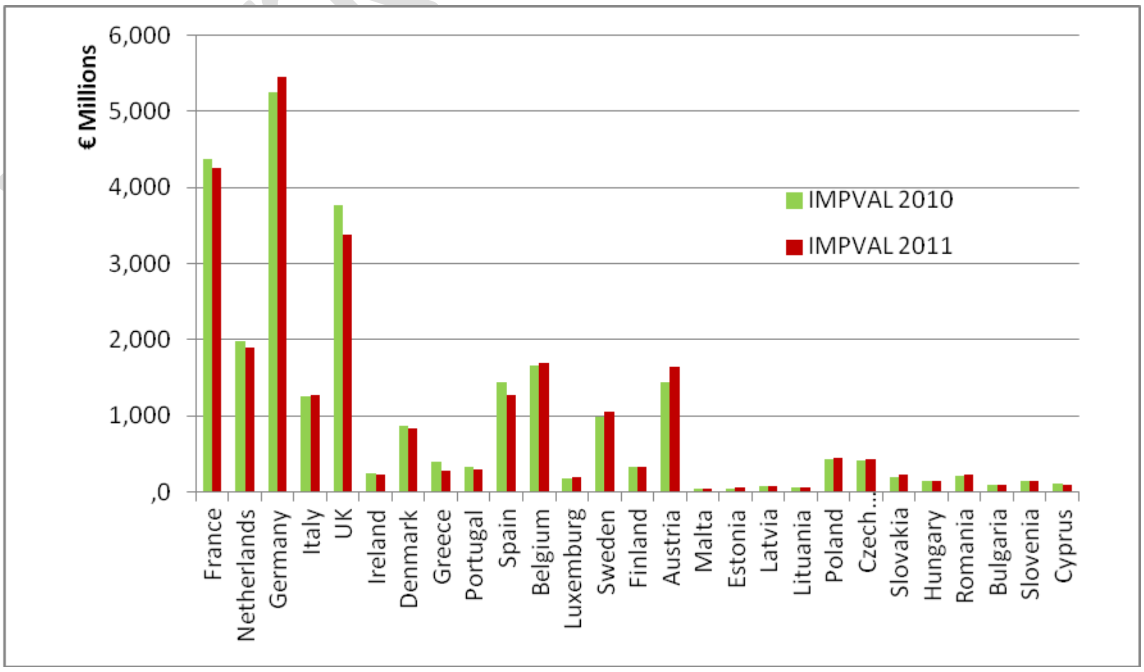


Figure 14. Imports of furniture by the EU-27 countries

Source: Eurostat. PRODCOM

Exports:

Relevant data of exports under study have been analyzed in this section. Furniture products are demanded all over the world and export represents a key activity for European companies of all sizes. In just one year, from period 2008 to 2009 exports decreased to 21%. However, furniture market has experimented in the last three years a positive trend in the context of the current economic crisis. In 2011, trade showed growth of over 21%, and it reached € 8764 million (from € 7225 million in 2009)[68].

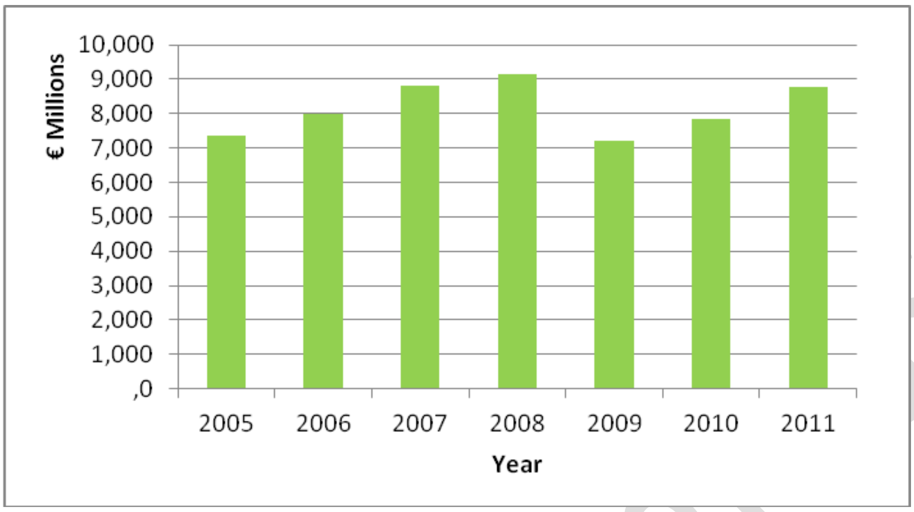


Figure 15. Evolution of furniture exports in the EU-27

Source: Eurostat. PRODCOM

Italy and Germany are by far the largest furniture exporters of the EU27 area (round 42% of total EU27). In 2011 German exports showed a growth of 11% compared to the previous year (see Figure 16), exporting similar values of Italy. The third European largest exporter is Poland (14% of total EU27) with levels far above the rest, and reaches over €4000 million. France, Netherlands, Denmark, Sweden, Spain and Belgium have values around €1000 million and finally, the rest of member states have values below €870 million.

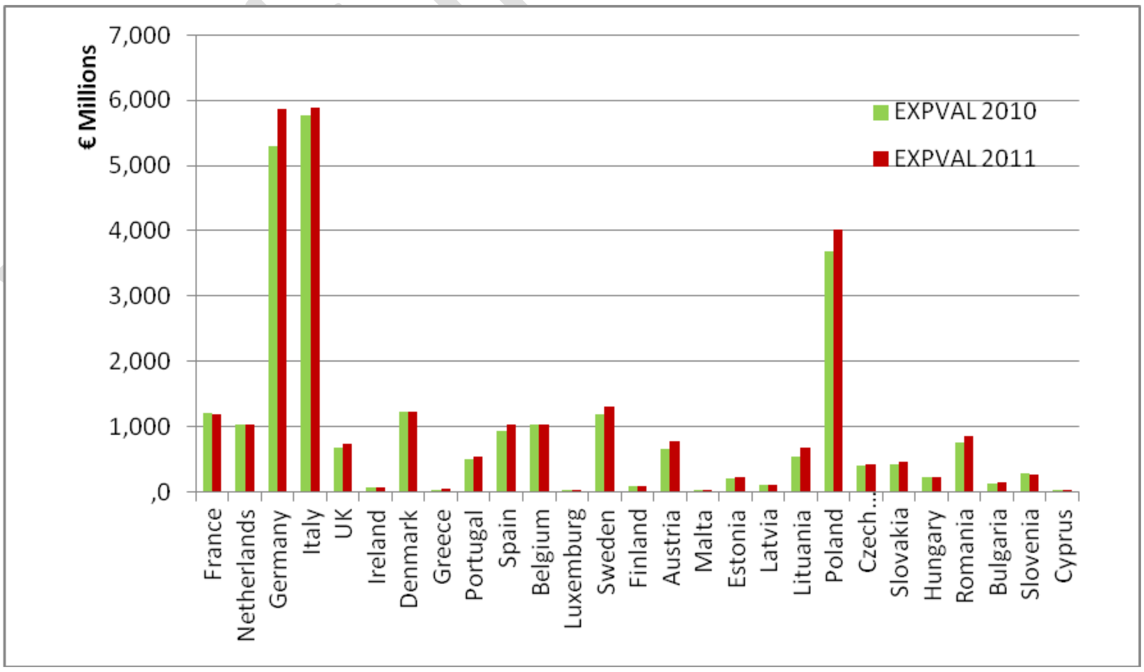


Figure 16. Exports of furniture by the EU-27 countries

Source: Eurostat. PRODCOM

3.3.2.2. Extra-EU furniture trade

This section analyzes the statistics on trade with third countries covering furniture imported and exported by the European Union. Statistic data have been extracted from the Market Access Database, which uses the HS codes to classify furniture products.

Imports:

According to the information published at the DG Enterprise website, the trade balance for furniture products has traditionally recorded a surplus. However, the balance has deteriorated dramatically from a surplus of almost €3 billion in 2002 to a deficit of €1.2 billion in 2008[69] due to international competition, and in particular due to an impressive progression of Chinese performance. To overcome this negative trend, EU furniture companies follow different competitive strategies based on promoting research and innovation, design and added value, skills and quality, knowledge and know-how and improvement of the access to third country markets.

In 2011 China accounted for 55.4 % of the EU imports. The second major supplier is Vietnam (5,34%), followed by Turkey (5,33%) and Indonesia (4,0%). Other less important suppliers are the United States (3,4%), Switzerland (3.3%), Bosnia and Herzegovina (2,5%), Malaysia (2.2%), Taiwan (2,1%) and Norway (1,8%)70. Figure 17 shows the import values (€ Millions) of the top 10 importers to the EU 27 countries in 2010 and 2011.

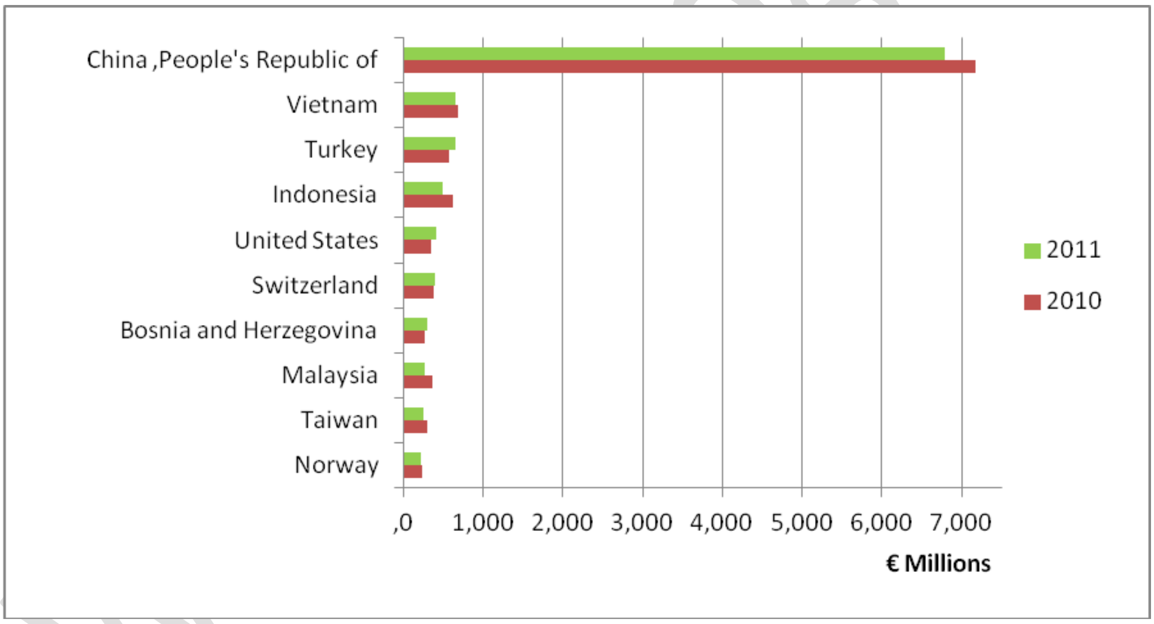


Figure 17. Top 10 EU suppliers of furniture products (codes 9401 and 9403)

Source: Market Access Database

Germany and the United Kingdom are the major importers of furniture coming from outside of the EU 27, with import values exceeding € 2500 million and representing about 45% of the total EU 27 import. France ranks at the third position with import value of over €1500 million.

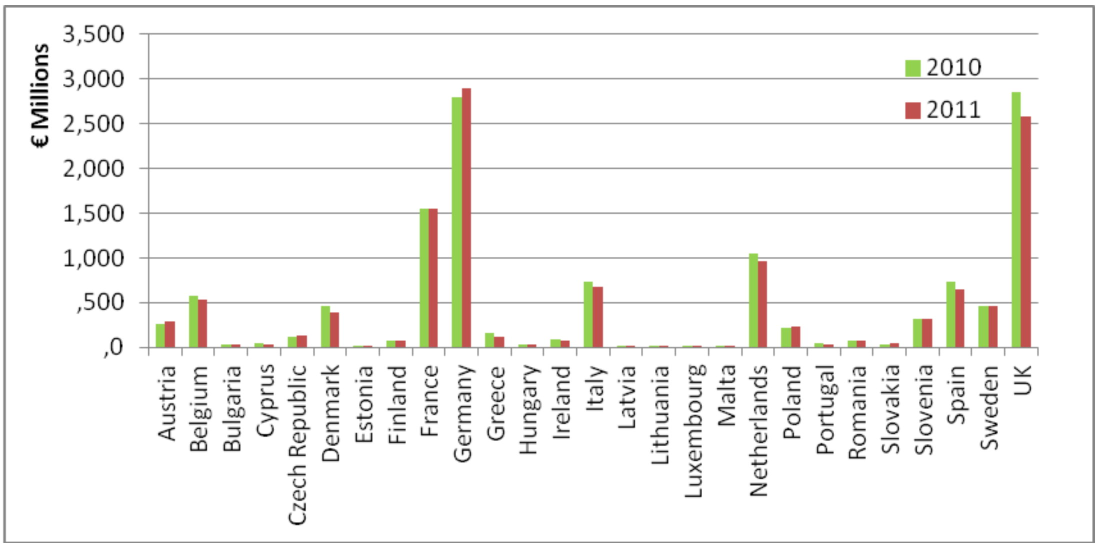


Figure 18. Import values coming from outside EU (codes 9401 and 9403)

Source: Market Access Database

Exports:

The main markets for the European exports outside the EU 27 are Switzerland (17.2 % in 2011), the United States (15.3 %), Russia (12,4%) and Norway (9,7%). Afterwards, there are China (5,4%), United Arab Emirates (2,8%), Japan (2,2%), Turkey (2,1%), Australia (2%) and Canada (1,9%). Figure 19 shows the export values (€ Millions) of the main markets in 2010 and 2011. One of the main reasons not finding developing countries like Indonesia, Vietnam, Brazil and India in the top ten export destinations are the high tariffs that they impose on imports. The EU tariffs or even China tariffs are fixed at zero or close to zero, while some developing countries that are important producers of furniture keep their tariffs at high levels. For example, for determined wooden furniture, Indonesia has a duty rate of 40%, Vietnam (25%), Thailand (20%), Brazil (18%) and India (10%)[71]. Consequently the trade balance with these countries is increasingly negative.

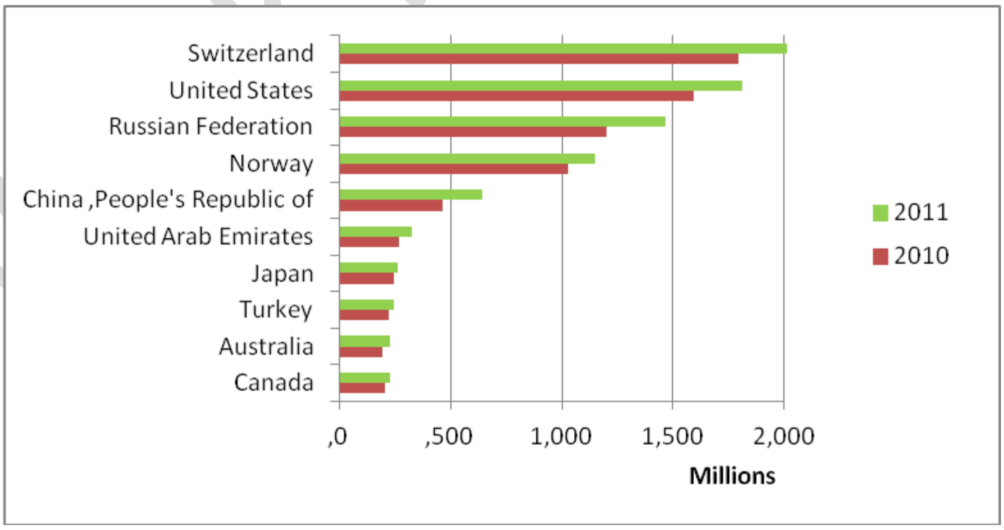


Figure 19. Main EU exports destination of furniture (codes 9401 and 9403)

Source: Market Access Database

The major trading partner of the EU 27 area in terms of exports is Italy, followed by Germany. In 2011, Italy accounted for 28% of exports, while Germany – 22%. The total value of exports outside the EU 27 amounted € 11808 million, increasing by 12,5% if compared to 2010.

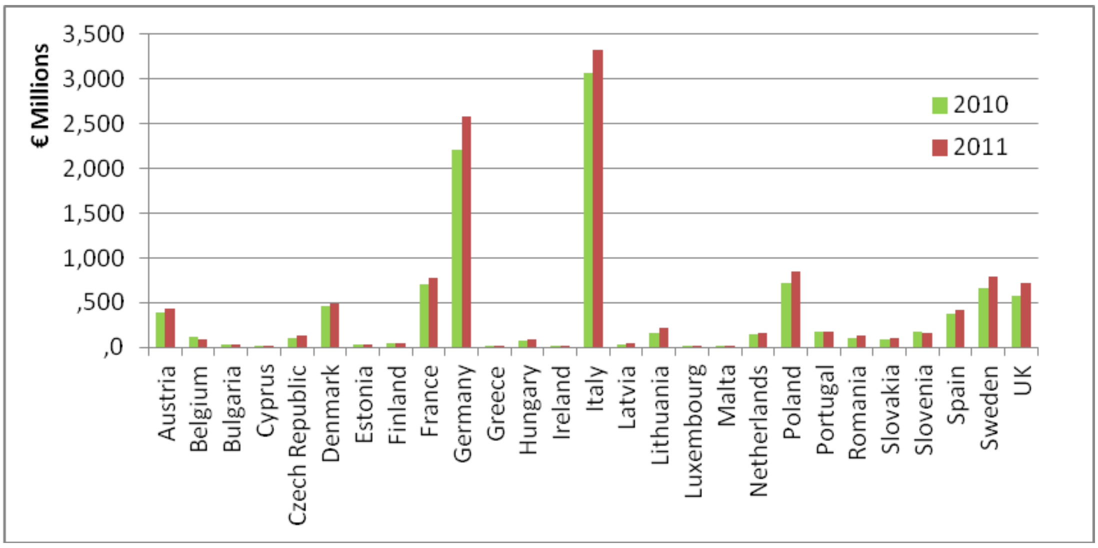


Figure 20. Export values outside the EU 27 area

Source: Market Access

3.3.2.3. Consumption

Although Eurostat does not provide information on consumption, values for apparent consumption have been calculated by adding production and import values and subtracting exports. European sales of furniture were valued at approximately € 50 billion in 2011, decreasing by 2,1% if compared to 2010. As shown in Figure 21, the market is still dominated by Germany, Italy, the UK and France, which between them accounted for over 69% of EU27 sales in 2011.Among these countries, Italy and France experienced a positive performance with a growth rate of 16,5% and 1,4% respectively, while consumption fell by 5,4% in Germany and 8,5% in the UK. Data referred to Germany have to be interpreted carefully because production values of office furniture and seats are not included in Eurostat due to confidentiality issues. In accordance with the information from the German Association of Office, Seating and Furniture (bso), in the first half of 2011 the sales[72] of office furniture increased by 21,8% and the sales of seating furniture increased by 20,2%. Despite the difficult economic conditions, German industry representatives expected a strong demand for office furniture within the second half of 2011. Nevertheless manufacturers are concerned regarding maintaining the margins, as the increased demand is accompanied by higher costs, especially those ones related to raw materials, energy and transport. Three of the countries most affected by the financial crisis recorded a significant decline of consumption: Greece (-26,3%), Portugal (-23,3%) and Spain (-17,9%).

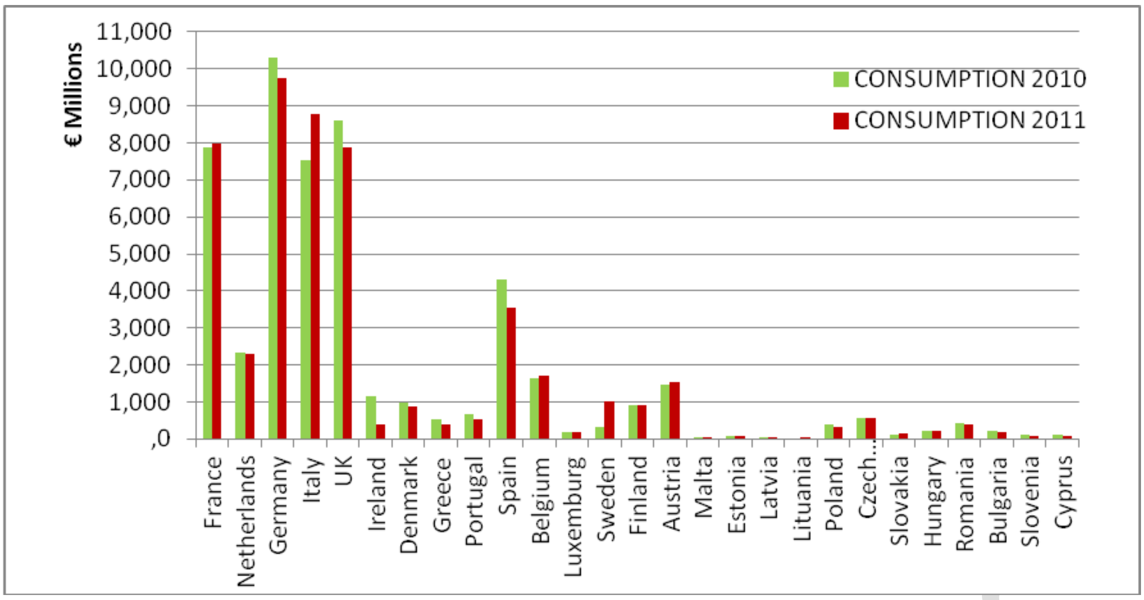


Figure 21. Apparent consumption of furniture in the EU 27 (2010-2011)

Source: calculated from Eurostat

Low cost furniture coming from emerging markets has avoid a highest decline in the demand, reaching new consumer groups previously unable to purchase or replace furniture as frequently.

Figure 22 shows how the EU 27 market was broken down in 2011 in terms of furniture consumption. Seats was valued over € 12000 million, followed by kitchen furniture (€ 8896 million), wooden bedroom furniture (€ 5902 million), wooden dining and living room (€ 4953 million), wooden office furniture (€ 4537 million), other wooden furniture (€ 3835 million), metal furniture (€ 3326 million), wooden furniture for shops (€ 2.854 million), metal office furniture (€ 1523 million), mattress supports (€ 1159 million), furniture of plastics (€ 458 million) and furniture of materials other than wood, metal or plastic (€ 95 million). Values of metal furniture, both offices and other metal furniture, are higher because there is no data reported in Eurostat of one of the major European producers, Germany, due to confidentiality issues.

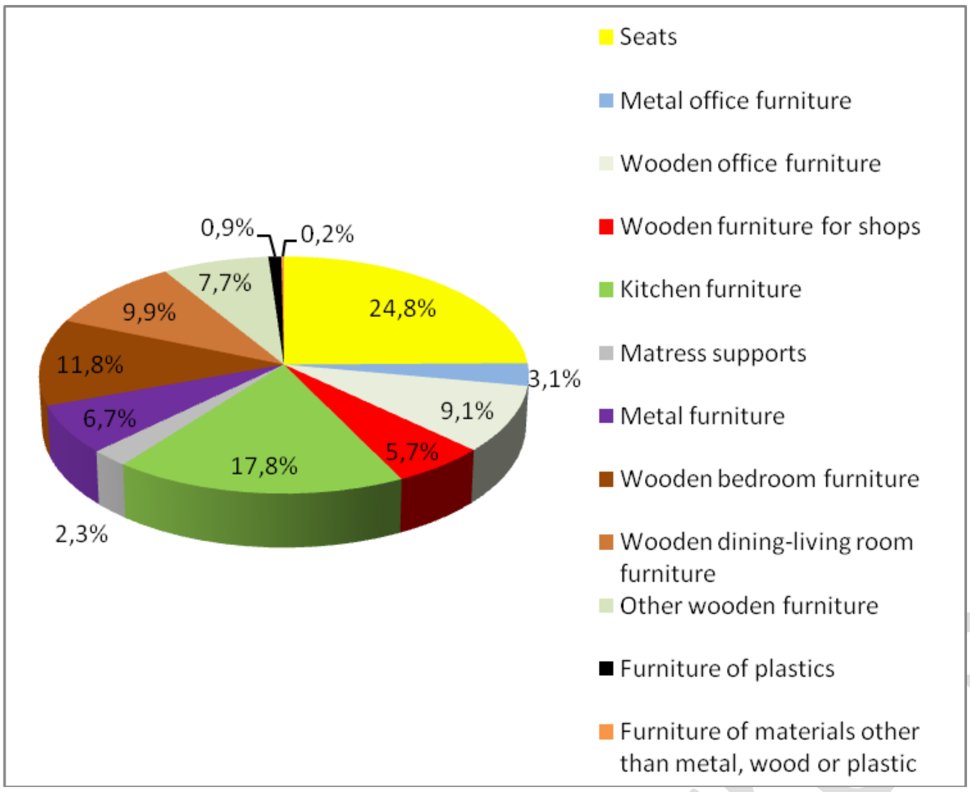


Figure 22. Apparent consumption (% by value) by type of furniture in the EU 27 (2011)

Source: calculated from Eurostat

Table 9 shows the main results of price surveys covering furniture and furnishings, carpets and other floor coverings across EU-27. Those surveys are part of the Eurostat-OECD Purchasing Power Parities (PPP) programme. The results of the surveys are expressed in Price Level Indices" (PLIs), which provide a comparison of countries' price levels with respect to the European Union average: if the price level index is higher than 100, the country concerned is relatively expensive compared to the EU average and conversely, if the price level index is lower than 100, then the country is relatively cheap compared with the EU average. Therefore, PLIs provide and indication of the order of magnitude of the price level in one country in relation to others.

Table 9. Price level index for furniture and furnishings, carpets and other floor coverings (2011)

EU27 country	PLIs
Belgium	99,2
Bulgaria	52,7
Czech Republic	75,3
Denmark	100,1
Germany	94,8
Estonia	85,9
Ireland	98,0
Greece	101,5
Spain	94,9
France	110,4
Italy	110,6
Cyprus	101,7

EU27 country	PLIs
Latvia	79,3
Lithuania	70,1
Luxembourg	107,2
Hungary	62,6
Malta	99,2
Netherlands	101,4
Austria	104,4
Poland	59,8
Portugal	94,4
Romania	63,9
Slovenia	88,6
Slovakia	78,4
Finland	106,0
Sweden	108,6
United Kingdom	111,2
EU-27	100,0

Source: Eurostat (online data code: prc_ppp_ind)

Price dispersion varies significantly between the most expensive country (United Kingdom with a PLI about 111,2) and the least expensive country (Bulgaria with a PLI of 52,7). Among the most expensive countries there are United Kingdom, Italy, France and Sweden, which have prices 11,2%, 10,6%, 10,4% and 8,6% over the EU27 average. Malta and Cyprus also show high price levels for furniture and furnishings. This may be due to their geographical position, causing higher transportation costs, but also the small size of internal markets. On the other hand, European Eastern countries have the lowest prices for furniture: Bulgaria, Poland, Hungary and Romania, with consumer prices 47%, 40%, 37% and 36%, respectively, below the EU27 average.

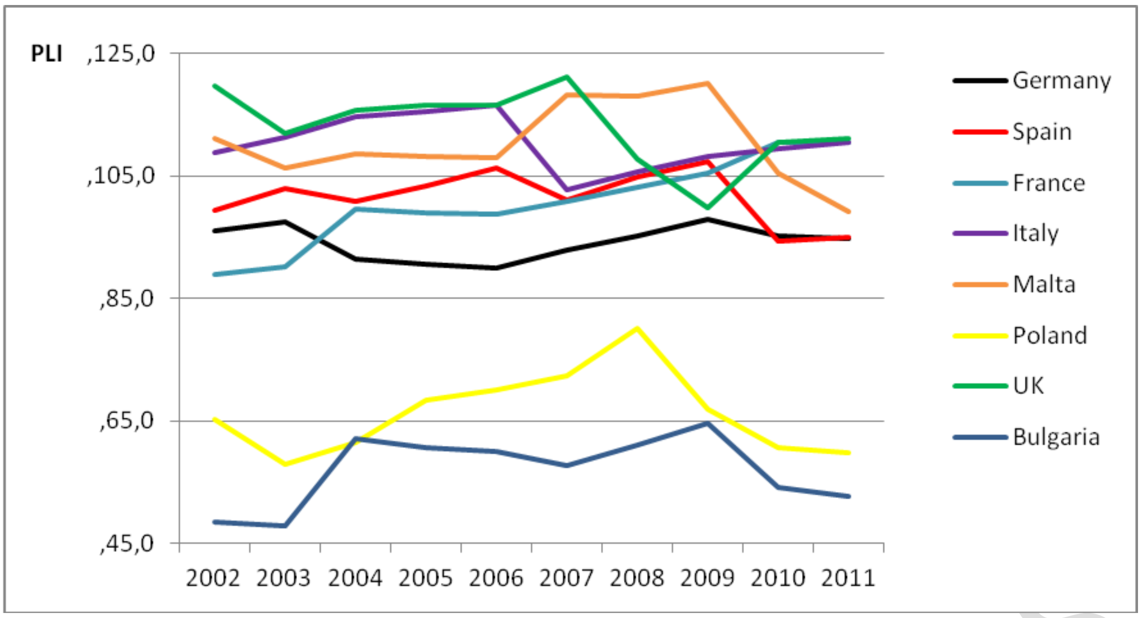


Figure 23. Evolution of price level index in some EU27 countries for furniture and furnishings, carpets and other floor coverings (2011)

Source: Eurostat (online data code: prc_ppp_ind)

3.3.2.4. Forecasts

The *World Furniture Outlook 2013* report[73] forecast a global increase in furniture consumption of between 3% and 4% for 2013, while worldwide GDP will increase by 3,6% this year, to 4,2% in 2014 and 4,4% in 2015. Emerging countries will have faster growth, at 5,6% in 2013, 5,9% in 2014 and 6,1% in 2015, while advanced countries are expected to grow at rates of 1,5% in 2013, 2,3% in 2014 and 2,6% in 2015. Furniture consumption in North America is expected to grow 2% in 2014, but the highest growth rates will be in Asia and in South America. According CSIL, the Western European furniture market decreased by 1% in 2012 and is expected to remain stable in 2013. Scandinavian countries will have a higher growth rate than the others. Central European countries and the United Kingdom will remain stable, while southern countries will further slowdown.

3.4. Structure of EU furniture sector

This section studies in detail the characteristics that determine the performance of the sector. The analysis has focused on identifying the key actors, examining the competition and significant strategies and the market potential in relation to the eco-label.

3.4.1. Industry background

The furniture industry is essentially an assembling industry which employs various raw materials (wood and wood based panels, metals, plastics, textile, leather, glass, etc.) to manufacture its products. In the last years, the EU furniture industry has improved the production quality, in terms of technical, design and fashion. The EU-27's furniture manufacturing (Division 31 according NACE rev.2) sector included about 130000[74] enterprises in 2010 that employed more than 1 million persons. Micro enterprises with less than 10 workers are the most common companies in the sector, representing around 86% of EU furniture companies. Generally, small companies act as subcontractors for larger firms providing to them components and semi-finished products for the finishing and assembling of furniture. The furniture manufacturing sector generated € 29000 million of value added.

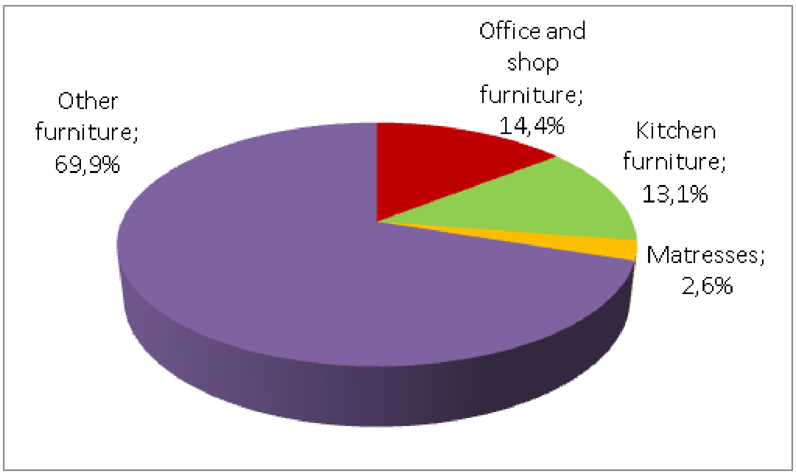


Figure 24. Sectoral breakdown of EU-27's furniture manufacturing companies in 2010

Source: Eurostat

Table 10. Key indicators of EU-27 furniture manufacturing (2010)

Main indicators	Value
Number of enterprises	130000
Number of persons employed	1080000[9]
Turnover (€ million)	95000
Purchases of goods and services (€ million)	66000
Personnel costs (€ million)	22000
Value added (€ million)	29000
Gross operating surplus (€ million)	7500
Apparent labour productivity (€ 1000 per head)	28,3
Average personnel costs (€ 1000 per head)	20,5
Wage adjusted labour productivity (%)	119
Gross operating rate (%)	7,9

Source: Eurostat

The apparent labour productivity of the European furniture manufacturing sector in 2010 was € 28000 per person employed, about one third lower than the non-financial business economy average. The average personnel costs were also low (€ 20500 per employee). The wage adjusted labour productivity ratio was 119% of average personnel costs per employee, a lower ratio than the average for the non-financial business economy (about 138%) and manufacturing (about 132%). Despite low wage adjusted labour productivity ratio, the European furniture manufacturing sector recorded a high gross operating rate (7,9%).

The structure of the furniture industry has changed in the recent years with the advent of the ready-to-assemble (RTA) furniture that allowed mass production. Generally, mass-produced large volume products are sold locally and for export, while high-end furniture is mostly purchased locally. RTA furniture requires investments in technological equipment, machinery and automation. RTA industry

[9] Data referred to year 2009. There is not available updated data.

is composed mostly by large firms because they are better able to deliver large volumes. However, RTA sector also include small companies that operate in product niches such as children furniture and entertainment furniture. In 2011, the RTA furniture production was worth € 8,073 million[75] and as shown in Table 11 this sector is performing better than the total furniture production. While the furniture production decreased by 12,7% between 2006 and 2011, the RTA furniture production increased by 3,9% in the same period.

Table 11. Percentage change from 2006 to 2011 of production, consumption, exports and imports in the EU-27 for total furniture and RTA furniture

Indicator	% change period 2006-2011	
	Total Furniture	RTA furniture
Production	-12,7 %	+3,9 %
Consumption	-7,9 %	+7,5 %
Exports	-4,0 %	-8,5 %
Imports	+5,9 %	+4,6 %

Source: adapted from the European market for Ready-To-Assemble furniture. World Furniture Online September 2012. CSIL .

The structural change in the furniture sector started years ago and is still under way due to many factors. Generally, it is less profitable to produce in advanced countries. Other relevant factors are the investments in new plants especially designed and built for exports (e.g. China, Vietnam, Poland), the sustained growth in the demand of furniture in emerging markets and the operations of large multinationals sourcing on a global scale like IKEA Group.

The most common problems faced by the European furniture industries are the following:

- Globalisation has affected the European furniture sector. Furniture prices are under severe pressure due to competition, in particular from Asian market. Import pressure from low-cost countries (e.g China, Vietnam, Indonesia).
- It is a sector mostly made by small and medium sized company, managed by their owners, with governance and reporting models that need to be updated.
- Many subsectors are facing investment stagnation, others have to deal with a over dimensioned production capacity
- Access to credit and loans - difficulties in finding resources to fund the costs of needed investments
- Unsatisfactory marketing skills and not well developed commercial structure to face internationalization
- Fragmentation of retail distribution structure that affects the entire value chain efficiency and all these deficiencies eventually further increase the price for final customers
- The need to strengthen protection of intellectual property. Poor ability of protecting investments on intellectual property.
- The furniture sector is facing a rise in the price of raw materials such as leather, plastics, natural fibres and petroleum derivatives. The sector is also facing competition for wood due to the growing demand to produce biomass energy.

3.4.2. Key actors

The goal of this section is to identify and classify the main stakeholders involved in the value chain of the different furniture products' markets. Figure 25 shows the actors involved in the value chain of the furniture manufacturing, composed by suppliers of raw materials (wood, metals, plastic, parts of furniture, adhesives, coatings, etc), designers, ICT and technological suppliers, packaging industry, furniture manufacturer, logistics, retailers and consumers. There is a close relation between furniture manufacturers and its supplying industries, while distribution is mostly carried out by specialised independent retailers.

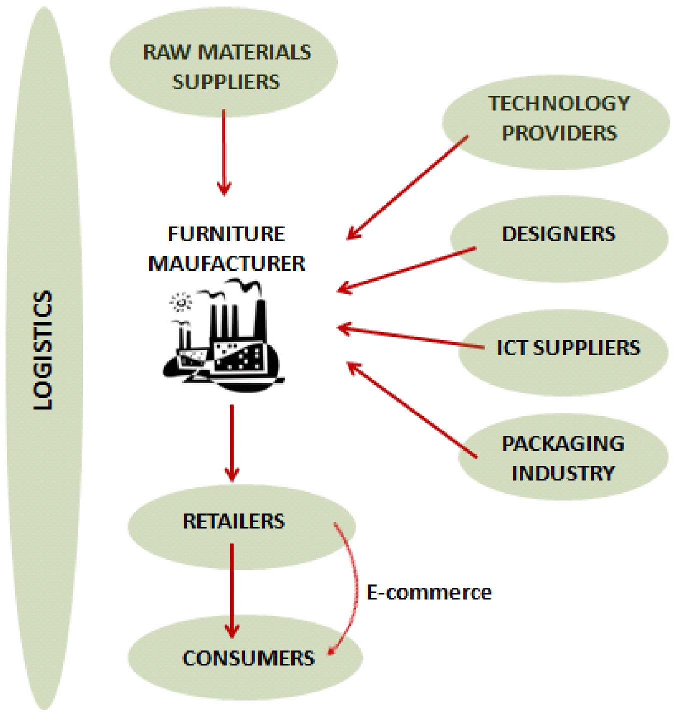


Figure 25. Value chain in furniture manufacturing

The sourcing of raw materials is an important step at the beginning of the value chain. Raw material suppliers supply the required raw materials to the furniture manufacturers. Technology providers, ICT suppliers and packaging industry are also part of the value chain. The amount of packaging used is generally high in order to prevent damages during deliveries. New criteria for furniture packaging are appearing with the aim to promote recyclability and raise the content of recycled material used. New demands on the design of furniture are growing in importance, especially for innovative and high-value added products, but also for those products which include environmental criteria in their design (e.g use of raw materials with a good environmental performance, recycled material, separable and recyclable, energy-efficient production, etc).

Generally, the retailer establishes the conditions for the manufacturer for the delivery of the furniture, because many of them have exclusive right of selling furniture in a specific region or country. The fact that most of the European furniture manufacturers are microenterprises with less than 10 workers and many retailers are large firms causes that generally retailers have greater purchasing power over the manufacturing. The process of off-shoring to low wage countries, such as Eastern Europe and also Asian countries, is a strategic decision to reduce economic costs in the manufacturing of standardized parts for furniture or for the whole production and assemblage of furniture. Going abroad in order to gain a competitive advantage allows manufacturing companies to enter low-wage countries and at the same time benefiting from moderate costs of production. For example IKEA, who is the largest retailer in the world, have the majority of the manufacturing companies in Eastern European countries. Swedwood is the name for the industrial group that manufactures IKEA products. In 2011, Swedwood had 16000 co-workers and 33 production units in 10 countries. Customers are the last step of the value chain. They purchase furniture through the internet or directly in the shop. Although e-commerce is increasing, consumers still prefer to see and touch furniture before making the decision to buy. Logistics take a relevant part in the value chain, covering all aspects of the movement and storage of the materials and goods, from the beginning of the production process to the end-of-life of the product..

The top global furniture manufacturers include companies like Swedwood, Natuzzi, Poltrona FRAU, Kinnarps, Steelcase, etc. The Swedwood Group, an integrated industrial group within IKEA Group, is the world's largest producer of wooden furniture. Natuzzi and Poltrona FRAU are the largest Italian furniture producers. Kinnarps and Steelcase are among the top 10 office furniture manufacturers, with a market share of 6,2% and 5,1% respectively in 2011 (Figure 26).

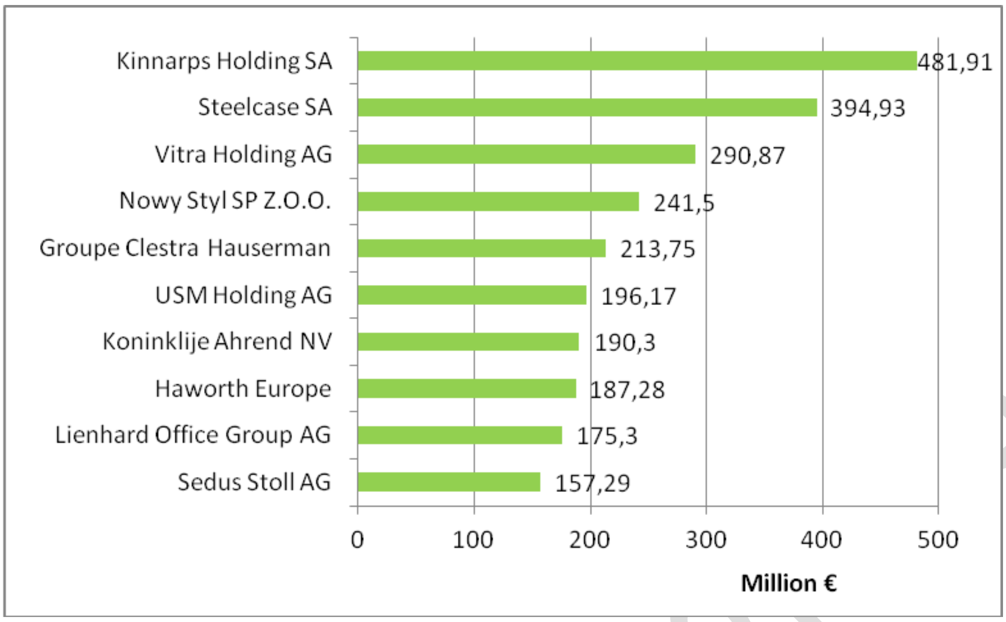


Figure 26. Sales in million € of the top 10 European office furniture manufacturers (2011)

Source: adapted from FEMB (Fédération Européenne du Mobilier de Bureau)

The furniture retailers leading the European market are listed in Table 12.

Table 12. Top 10 European furniture retailers (2011)

Top 10 companies	
1	IKEA GROUP, Sweden
2	Home Retail Group, United Kingdom
3	Steinhoff International Holdings, South Africa
4	XXXLutz Gruppe, Austria
5	Jysk Holding, Denmark
6	Otto Group, Germany
7	Krieger-Gruppe, Germany
8	But, France
9	De Mandemakers Groep, The Netherlands
10	John Lewis, United Kingdom

Source: FENA Newsletter. May 2011. European Federation of Furniture Retailers.

The European and also the world's largest furniture retailer is the IKEA-Group, with total sales of EUR 24.7 billion in 2011, increasing by 6.9% compared to 2010. About 79% of sales were produced in Europe, 14% in North America and 7% in Russia, Australia and Asia[76]. Despite the global economic crisis, IKEA has maintained stable growth and profitability in almost all countries and with biggest gains in Poland, Russia and China. The strong brand of IKEA and low prices helped it to weather the recession period, even in those European countries most affected by the crisis, like Spain where sales increased by 8,2% in 2010 and Italy where sales rose by 11,3%[77].

Far away of IKEA's sales, the second largest furniture retailer is the Home Retail Group from UK, with estimated sales EUR 4.465 billion[78]. Thanks to the acquisition of the French Conforama Group (a network of more than 200 stores France and French overseas departments and territories as well Spain, Switzerland, Portugal, Luxembourg, Italy and Croatia), the Steinhoff International Holdings Ltd of South Africa is now the third largest retailer with sales of EUR 4.202 billion[29]. Among the top ten largest furnishing trade groups remarks XXXLutz Gruppe with a turnover of around EUR 2.8 billion. Today it operates 193 furnishing stores in Austria, Germany, the Czech Republic, Slovakia, Hungary, Sweden, Slovenia, Croatia and Serbia with more than 17,700 employees[79].

3.4.3. Competitive strategies

This section covers general aspects about the models and competitive strategies carried out by stakeholders of the sector. The goal of this analysis is to understand how companies tend to compete and which strategies are used to diverge from the competitors.

Generally, a European furniture business model is based on production, without taking into account the value generation for the consumer. European companies have to compete with emerging countries, which have competitive advantages in terms of lower labour costs, known and accessible technologies, and import facilitating factors. To overcome this threat, the European furniture industry should update the current business model into a new one based on the added value created for the consumers. It is very important to know the consumers' behaviour; their characteristics, lifestyles, preferences, etc. (section 5 explores this topic in more detail) in order to adapt the furniture product to the consumer demands, making the product more valuable. Table 13 summarizes the characteristics of the current business model followed by most of the European companies and on the other side the characteristics of a new business model based on the added value created for the consumers.

Table 13. Differences among a traditional business model and a business model based on added value generation

Traditional business model	Business model based on value generation
Oriented to the furniture production	Oriented to the consumer
Based on the traditional value chain: supplier - manufacturer – retailer and based on the individual capabilities and resources of the companies	Operative efficiency search, improving the inter-cluster cooperation
Local and national activity approach	Global approach of the activity
Company size as a problem	Flexible organizations to apply (strategy, organization, resources and capabilities, knowledge and technologies)

Source: Adapted from First Project co-funded by the European Union. UEA European Furniture Manufacturers Federation. Furniture Industry in restructuring: systems & tools

The strategy of differentiation is based on the competitive advantage by creating a furniture product with certain characteristics (quality, innovation, price, environmentally friendly, etc) that are granting a difference compared to the products of the competitors. Some competitive strategies used in the sector have been characterized below, based on the results of the market questionnaire received by some European furniture associations and manufacturers, but also from existing market reports[80]:

Price structure. Price is one of the first indicators used to compare a furniture product amongst competitors. Establishing a successful price is a key aspect in the market (entry) strategy. Large retailers purchase in substantial quantities, increasing pressure on prices and margins in the trade channels. The main factors that affect the price structure are:

- The production costs, import duties, incoterms, anti dumping levies and VAT
- Discount structure and credit terms offered by local competitors
- Retail prices of competitors' products
- Select the right trade and distribution channels
- Additional costs for product adaptation, logistics and transportation, packaging, marketing, etc.

The importance of innovation. The European furniture industry is today a mature sector where companies have difficulties to compete with emerging countries. Innovation is one of the strategies that can help to increase competitiveness and to reduce costs. Innovation includes automation of business processes, the use of Computer Aided Design or Manufacturing (CAD/CAM) and the introduction of new materials that are more resistant or cheaper than previous ones. Strategies based on creativity, quality and differentiation of products should be pursued by companies in order to sustain a certain level of growth. Differentiation of products is not only referred in terms of quality or price, but rather in terms of design, style and functionality with the aim to satisfy the customers preferences. Companies have to find the paths for product innovation such as changing the design of the product, introducing new materials (e.g surface treatments[10], recycled materials, …), environmentally-friendly design, use of ICT tools like 3D modeling tools, use of the internet and development of e-business to provide services to new market segments, etc. The introduction of 3D modelling tools as well as other software tools can increase the efficiency in the product development process. However, some barriers have been identified for the usage of these tools in small companies, due to more resources are needed: time requirements, money to purchase hardware and software, training costs and qualified personnel.

Environmental approach. The growing environmental concerns have also led to the development of eco-friendly furniture. Some companies (e.g Steelcase and Formway) have decided to take into account environmental issues as a way to gain competitive advantage, using for example software tools for the Life Cycle Assessment (LCA) of furniture products. LCA methodology allows that product designers are aware of how choice of material influences the environment, and how they, in their design work, might create more sustainable products. An LCA of a furniture product can cover all the production processes and services associated, including raw materials extraction, product manufacturing, transportation, retailers, use of the products in customer's home and its recycling or disposal. Some companies succeed in converting the burden of additional costs (more resources are needed) into a competitive advantage, as they base most of their communication and marketing on the environmental characteristics of their products. Annually, Interbrand and Deloitte rank the world's top brands[81] on the basis of their environmental performance as well as the public's perception of their green credentials. IKEA Group is the only furniture company among the 50 Best Global Green Brands, which holds steady at 39th position of the ranking in 2012. IKEA makes a large effort to gain publicity in the sustainability field. IKEA Green Tech, a company owned by the IKEA Group, is in charge to invest in innovative technologies and services relating to energy, water, waste, advanced materials in order to improve the sustainability of the IKEA business activities. In 2012, the company increased the proportion of total wood (solid and board) coming from forests certified to

[10] innovative materials made of natural materials to be used for making furniture. Among its exclusive properties are its great hardness, resistance, durability, ease of repair, non-porous surface, low maintenance requirements and easy cleaning.

Forest Stewardship Council (FSC) standards to 23% (16% in 2011). Approximately 85% of packaging is made from recycled materials. In 2012 the company invested heavily in wind farms and solar panels, having at the end of the year 250,000 solar panels on their buildings and 83 wind turbines in operation. The renewable energy produced in 2012 was equivalent to 34% of total energy consumption. New projects up to 2015 will take total investments in renewable energy (focusing on wind and solar) to up to €1.5 billion.

Ecolabel as a source of differentiation. There are a wide variety of labels in the market which certify wood itself like PEFC and FSC, but also there are other certifications able to certify furniture products other than wood, such as Nordic Swan and Blue Angel. However, the requirements established in ecolabels do vary considerably. Furniture sector tend to perceive environmental certifications as an available tool to improve its position against their competitors:

Ecolabelling is a simple and cost-effective way to communicate environmental aspects and commitment to purchasers and consumers.

Environmental issues are complex. It can take a long time and extensive resources to gain an understanding of a specific area. Ecolabelling facilitates this process.

Some certifications like EU Ecolabel, Nordic Swan, Blue Angel, etc not only cover environmental issues but also quality requirements, since environmental and quality concerns often go together. It means that an Ecolabel licence can also be seen as a mark of quality.

Environmental demands have become a standard in public procurement processes, especially in Nordic countries.

Reduce lead times. Reduction of lead times is a success strategy for EU furniture manufacturers, improving their competitiveness mainly for two reasons: the first one because enhance their reputation towards customers and last but not least because many extra-EU manufacturers find difficult to match. Therefore reducing lead times, minimize logistical costs and reach the customer at the lowest possible price. The implementation of proper ICT and e-business tools, such as Supply Chain Management systems (SCM), can help to reduce costs and time savings thanks to a better production planning, warehousing and inventory control. However, the usage of SCM systems are still limited to larger companies while SME's face relevant barriers to implement them, mainly in terms of costs and complexity of technologies.

Export into emerging markets. Stagnant demand of furniture will continue in Europe in the coming years (with the exception of Eastern Europe), while the growth of furniture demand will be strong in emerging countries, especially in Asia and South America. The expected growth of furniture demand in emerging countries is causing that more and more companies decide to export to these markets. The high-end furniture industry[82] is also experiencing a rise in the demand in emerging countries, especially in Russia, Brazil, China and India, where the number of luxury buyers is increasing. This affects the demands for home furniture since more people now have the financial strength to decorate their homes.

Communication strategy beyond advertising. The key players also attempt to gain credibility in local markets and thereby they build tacit endorsement for their products through the sponsorship of activities, conferences and campaigns, undertaken by local professional bodies. Trade fairs, web-site advertising, magazines, newsletters and TV programmes are the most common methods used to promote furniture sector. Furniture fairs are highly effective means of reaching potential customers, although this can be expensive. An innovative strategy is expected to be implemented in some IKEA stores, based on an interactive television that allows viewers to purchase advertised products with just their remote controls.

3.4.4. Current and future potential for market penetration of EU Ecolabel and GPP

After more than three years of the approval of the ecological criteria for the award of the **EU Ecolabel** for wooden furniture, nowadays there is only one furniture product ecolabelled[83] by the EU Ecolabel, which was certified in Poland in 2012. The lack of furniture products certified in the market is in part due to the exclusion of both non-wooden furniture and wooden furniture with less of 90% w/w of solid wood or wood-based materials. As described in chapter 3.3.1.2 (see Figure 9), from statistical data analyzed from Eurostat it can be deduced that more than 20% of EU production is non-wooden furniture, and hence this significant share of the market is excluded from the scope. Although more than 56% of the production is classified as wooden furniture, few products are composed at least by 90% of wood. A market questionnaire was provided to European stakeholders (mainly manufacturers and furniture associations) in order to determine the average composition of different types of furniture: domestic indoor furniture, domestic outdoor furniture, professional office furniture, school furniture and hotels and restaurants furniture. The results of the questionnaires are shown in Table 14. The materials used can vary considerably depending on the type of furniture and on its intended use, Stakeholders generally agree that in most of the cases wooden represents below 90% w/w. Among the nine stakeholders who answered the questionnaire, two of them were European furniture associations (stakeholders number 5 and 8) who represent over 2,900 furniture manufacturing companies. The other seven stakeholders are furniture manufacturing companies. The average of the results shows that wooden is the main material used for all types of furniture, especially for domestic indoor furniture (72% by weight). Metal is usually the second material most used, in particular for school furniture (37% by weight) and office furniture (28%), while plastic is used mostly for outdoor furniture (27% by weight).

Table 14. Percentage of weight of the component materials in different types of furniture

Type of furniture	Material	Stakeholder nº									Average
		1	2	3	4	5	6	7	8	9	
Domestic indoor furniture (%)	Wooden	75	75	-	60	75	90	60	70	-	**72**
	Metal	15	20	-	10	8	5	20	5	-	**12**
	Plastic	5	5	-	25	3	5	20	5	-	**10**
	Other	5	0	-	5	14	0	0	20	-	**6**
Domestic outdoor furniture (%)	Wooden	30	30	-	40	30	-	75	75	-	**47**
	Metal	40	30	-	25	30	-	5	5	-	**23**
	Plastic	20	40	-	30	30	-	20	20	-	**27**
	Other	10	0	-	5	10	-	0	0	-	**4**
Professional office furniture (%)	Wooden	35	68	30	45	45	85	60	80	30	**53**
	Metal	30	30	40	25	40	10	30	10	40	**28**
	Plastic	25	2	15	25	5	5	10	5	10	**11**
	Other	10	0	15	5	19	0	0	5	20	**7**
School furniture (%)	Wooden	35	-	25	35	40	-	50	80	40	**44**
	Metal	30	-	55	45	50	-	30	10	40	**37**
	Plastic	25	-	15	15	5	-	20	10	20	**11**

	Other	10	-	5	5	5	-	0	0	0	**4**
Restaurant & Hotel furniture (%)	Wooden	35	-	-	50	40	-	50	60	40	**46**
	Metal	30	-	-	35	20	-	30	5	20	**23**
	Plastic	25	-	-	15	20	-	20	5	20	**18**
	Other	10	-	-	5	20	-	0	30	20	**14**

Source: Market questionnaires answered by furniture manufacturers and furniture associations

Alternatively, in order to complete the data gathered from the market questionnaires a market research has been done. According to the Swedish furniture industry the average Swedish furniture product consists of 70w% wood (-based material), 15w% padding materials (mainly polyurethane and polyester foam), 10w% metals and 5 w% other materials (plastics, textiles, glass, etc.). In addition, in the current EU Ecolabel there is a criterion that restricts the weight of non-wooden materials to 3% of the total weight of the product, and the total combined weight of such materials shall not exceed 10% of the total weight of the product. For example, the amount of metals in office or school furniture is much higher and as a consequence a lot of products are excluded from the scope.

Concerning **Green Public Procurement (GPP)**, in 2008 the European Commission set a target that, by 2010, 50% of all public tendering procedures should be compliant with core EU GPP criteria for ten priority product groups, including furniture. In 2011 the European Commission commissioned a study in order to verify if the target of 50% has been met. Due to the lack of statistics on GPP in the Member States, a survey was conducted over 850 public authorities from 26[11] EU countries. The study[84] collected information on 151 furniture contracts signed by public authorities in 2009-2010, which 91% of the contracts were for indoor furniture and 7% for outdoor furniture. The remaining 2% it was not specified. The results of the study indicate that only 14% of European furniture contracts comply with all EU core GPP criteria and about 50% of furniture contracts include at least one EU core GPP criterion. In terms of monetary value, contracts including all GPP core criteria represented 25% of the sample while 41% contain at least one GPP core criterion. Figure 27 shows in more detail the percentage of furniture contracts by country that include at least one GPP core criterion and those ones that takes into account all GPP core criteria.

[11] The missing country is Luxembourg, for which no responses were received.

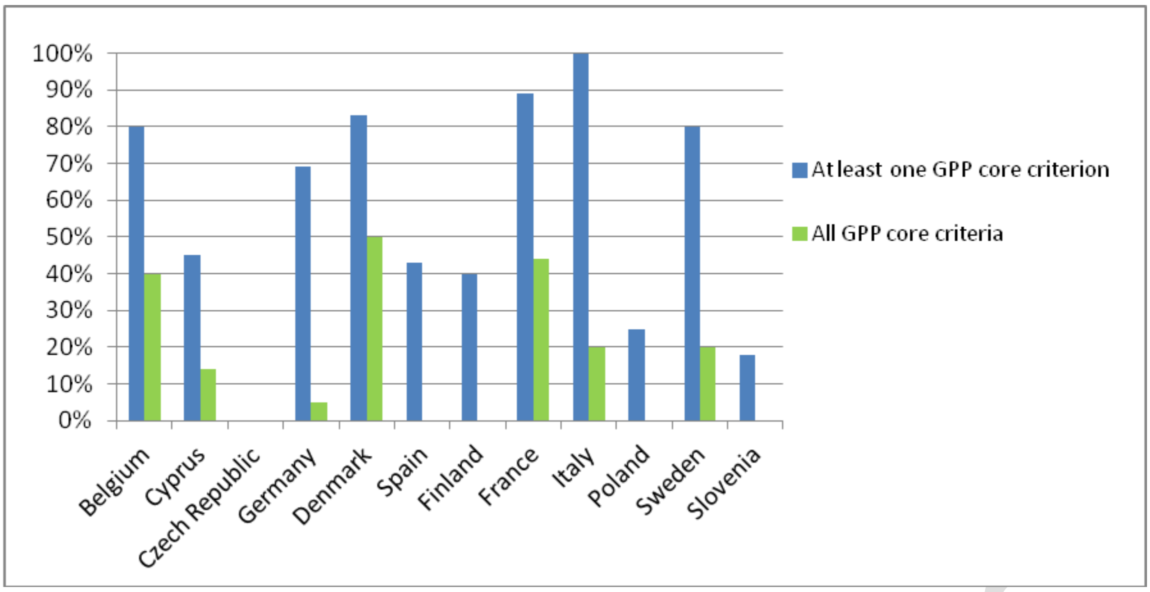


Figure 27. Number of furniture contracts (%) by country including at least one GPP core criterion or all GPP core criteria

Source: data processed from "The uptake of Green Public Procurement in the EU-27" report. Centre for European Policy Studies in collaboration with College of Europe. February 2012.

The data gathered from Ireland, Netherlands, Portugal and Slovak Republic has not been considered because they did not provide sufficient information. In addition, the countries that reported less than 5 furniture contracts have not been taken into account. These countries are Austria, Bulgaria, Estonia, Greece, Hungary, Lithuania, Latvia, Malta, Romania and the UK. As regards the inclusion of all GPP core green criteria in a furniture contract, the best performing country in 2009-2010 was Denmark (50%), followed by France (44%), Belgium (40%), Italy (20%), Sweden (20%), Cyprus (14%) and Germany (5%), while countries like Spain, Finland, Czech Republic, Poland and Slovenia did not have any furniture contract including all GPP core criteria. In addition to that, Italy is the best performer when it comes to the inclusion of at least one GPP core criterion for furniture, as all of the contracts reported include at least one GPP core criterion. The worst country in terms of GPP was Czech Republic, which did not include any GPP core criterion in their furniture contracts.

Within *The uptake of Green Public Procurement in the EU-27* study the following four core criteria were analyzed: 1) the maximum level of substances harmful to human health or the environment; 2) packaging materials; 3) durability and/or reparability 4) legally sourced timber; with the aim to determine their level of uptake. The criteria most used in furniture contracts by public authorities are the harmful substances (included in the 30% of tenders) and packaging materials (30%), followed by durability and/or reparability (28%) and finally requirements on the sustainable and lawful origin of timber (21%).

Currently, some initiatives are being developed in order to promote GPP such as in Basque country, where IHOBE[12] with the support of Habic Cluster[13] have initiated a review process to modify the current criteria in the public procurement, with the aim to introduce more environmental criteria in upcoming furniture contracts.

In summary it can be said that the current market context is favorable both to host Ecolabel furniture products and to promote GPP. Companies gradually understand that consumers really want products that respect the environment. However, to achieve a significant impact the consumer

[12] IHOBE is the Basque Environmental Management Authority

[13] Habic is the cluster of Habitat and the Contract of the Basque country, which brings together the main furniture companies

must be well informed to understand what the Ecolabel represents. If it is done right, Ecolabel can be an added value for the product placed on the furniture market.

3.5. Consumer behaviour

The aim of this section is the identification and prioritization of the factors affecting the consumer behaviour in the purchase of furniture products. The factors that actually influence the consumer choice of the furniture are analyzed here. The analysis of consumer trends is becoming a basic input for furniture companies to correctly orient their offer and succeed with their products. Consumer trends help to predict which product could be launched and to determine the response from potential users. Also, user behaviour must be analyzed to assess the degree of acceptance of EU Ecolabelled products. Consumer trends are presented below with the aim to understand better consumer preferences. In order to reach this purpose a literature review has been conducted.

3.5.1. Factors that influence consumer preferences

One of the major issues for the furniture industry is to understand the consumer preferences. As a consequence of the internationalization of enterprises, manufacturers are faced with a need to analyze new markets they are going to enter. Consumer behaviour should be well known and taken into account when a furniture product is designed with the aim to grab the consumer's sympathy and attention, and hence to satisfy their preferences. The major factors that influence user's behaviour can be grouped in the following:
Personal: age, occupation, economic circumstances, lifestyle, personality
Social: family, roles, statuses
Psychological: motivation, perception, learning, attitudes
Cultural: culture, subculture and social classes.
Manufacturing companies entering foreign markets have to keep in mind the influence of the cultural factors in consumer choice, *e.g.* aesthetic perceptions can be different. User behavior may vary among different societal groups or even from country to country. For example, Scandinavian countries generally prefer simple geometric furniture, bright mild colors and natural materials like wood.

Furniture must meet several basic criteria to satisfy consumer's behaviour: it should be comfortable, functional and affordable, appropriate for its purpose, have a minimum level of quality, and there should be enough space for the furniture. Moreover, more and more consumers take sustainability as a relevant factor in their consumer intent and behaviour.

According to previous studies[85] related to the user behaviour in furniture choice, quality, price and the appearance factor are positioned among the top 3 considered by the buyers. The table below summarizes the main roles of the appearance factor for consumers.

Table 15. Roles of the appearance factor for consumers

Appearance role	Influence on consumers
Attention-grabbing	Draw consumer attention in store or internet
Categorization	Influence ease of categorization
	Offer possibility for differentiation from the product category
Functional	Show features/ functionalities
	Serve as a cue for features/ functionalities
	Serve as a cue for technical quality
Ergonomic	Show parts for consumer-product interaction
	Show consequences of use of overall

	appearance aspects (e.g. size, roundedness)
Aesthetic	Serve as a basis for aesthetic appreciation
	Fit with home interior and other products owned
Symbolic	Serve as a basis for symbolic product associations
	Communicate brand image

Source: Adapted from the report "The consumers' furniture preferences in different markets". 2011. Daria Troian. University of Trento

According to the previous study mentioned, the aesthetic and symbolic roles were considered most important for consumers. Price has been always an important factor, especially in a difficult economic situation. The current recession is affecting many families, who can not afford new furniture. The sale of less houses causes that there are less consumers who need new furniture. Also consumers' preferences differ in function of the socioeconomic, psychological and cultural characteristics. Other factors, such as the product availability, information availability, access, speed of delivery or amount of shopping time required, have an impact on the choice of a retail environment.

A particular study[86] describes which factors affect the customers' decision to visit IKEA, the largest furniture retailer, and how these factors in the retail environment affect customer experience. The findings indicate that consumers who choose to purchase in IKEA base their decision mainly on cost-advantages and the size of assortment. Social factors with along social activities also have an impact on the customers. The availability of café, restaurants and a baby-sitting service are services well-valued by customers.

3.5.2. Environmental factor, a new trend affecting consumer behaviour

The following paragraphs are focused on the Italian consumer behaviour, which is considered one of the most important furniture markets, both in Europe and worldwide. According to the results extracted from a report performed by FederlegnoArredo[14] added values such as environmental issues, technological innovation, web 2.0 and certifications (safety, Made in Italy, social responsibility, etc) are considered in the consumer choice. 2500 purchasing managers were asked for which features or added-values they would be willing to pay 10% more. From Figure 28 it can be observed that the most accepted characteristic for which consumers are willing to pay extra is the warranty that replacement furniture parts would be provided for a minimum number of years (nearly 32% of the consumers). The second feature most accepted (about 31% of consumers) is the use of natural materials. The bar graphs represented in green are those characteristics related to environmental aspects.

[14] Federlegno-Arredo is the Italian Federation of Wood, Cork, Furniture and Furnishing Industries. Federlegno-Arredo represents the entire woodworking and furniture industry, from raw materials to finished products, and is the official dialogue partner of public and private institutions both in Italy and abroad.

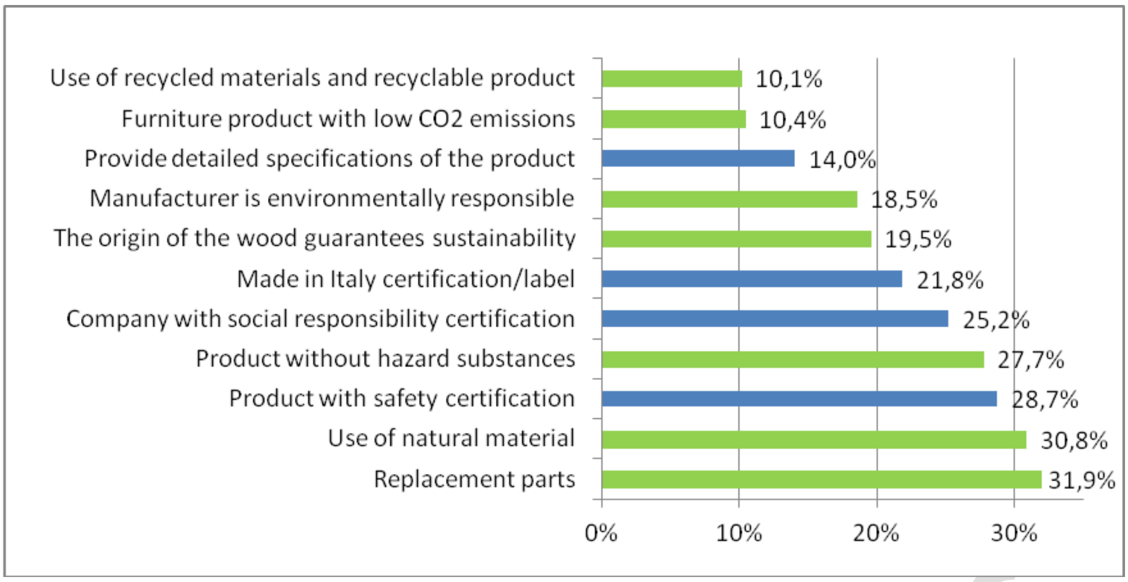


Figure 28. Characteristics that consumers are willing to pay 10% more for furniture products
Source: adapted from the report "Voglio di Più. Ambiente, Tecnologia e Web 2.0". FederlegnoArredo.

The second part of the study analyzes the consumer behaviour focused on the following four environmental characteristics:

a)Sustainable origin of the wood
b)Use of recycled materials and recyclable products
c)Furniture produced with low CO_2 emissions
d)Environmentally responsible manufacturer

The purchasing managers were asked whether they are willing to pay 10% more for a furniture product with at least two of the environmental characteristics mentioned above. The most preferred characteristics are the sustainable origin of the wood combined with an environmentally responsible manufacturer, which represent 3,2% of the consumers choice. In total, 11,9% of consumers accepted to pay more. This represents about 3,3 million of Italian consumers. Among the respondents who are willing to pay more, about 76% have medium-high and very high incomes. It is interesting to remark that consumers receptive to environmental protection generally consult relevant websites to find detailed specifications of the product, when comparing to those consumers with less environmental awareness. Table 16 summarizes the results of the survey.

Table 16. Environmental preferences of the Italian furniture consumers

Sustainable origin of the wood	Use of recycled materials and recyclable products	Furniture produced with low CO2 emissions	Environmentally responsible manufacturer	Purchasing managers	
				Number	Percentage (%)
√			√	893000	3,2
√	√	√	√	530000	1,9
√		√	√	446000	1,6
√		√		223000	0,8
	√	√		223000	0,8
		√	√	223000	0,8
√	√	√		195000	0,7

√	√		√	195000	0,7
√	√			167000	0,6
	√		√	167000	0,6
	√	√	√	28000	0,1
			TOTAL	**3290000**	**11,9**

Source: adapted from the report "Voglio di Più. Ambiente, Tecnologia e Web 2.0". FederlegnoArredo.

From the results of the study, it can be concluded that consumers are not aware of the environmental specifications of the furniture products that they purchase. This is, at least in part, due to a lack of ecolabels and certification schemes in the furniture sector to promote the information to consumers. The survey reflects that there is a high potential to grow the awareness of consumers to purchase ecofriendly furniture products (11,9% of consumers would accept to pay more for a sustainable product).

Another evidence of the high potential of green products in the market is based on a recent survey[87] conducted in China, the major furniture producer in the world, the major furniture exporter to the EU-27 and the fifth country in the rank importing EU furniture. It demonstrates a growing awareness and desire among urban Chinese consumers for green products that offer sustainability benefits. According to the Global Green Brands survey 2011[88], the interest of European markets to buy environmentally friendly products has grown compared to previous years as well as the predisposition of a higher payment for their purchase. In Germany, 30% of respondents of this study said they had bought more green goods in the current year than in previous, up from 21% in 2010. Despite this, we must evaluate each case separately because, for example, in the United Kingdom, 40% of respondents said they were not willing to buy a more expensive product just because it is green. The environmental situation of each country affects the consciousness of users and therefore the demand and willingness to pay for these products.

In 2011, IKEA performed a survey[89] to 8500 consumers and 1250 IKEA co-workers in eight countries on three continents in order to understand perceptions of the brand and its sustainability efforts. The results showed that consumers welcome help from IKEA on integrating sustainability into their lives at home. They also want IKEA to take an active role beyond the company's own operations. In 2012, IKEA carried out a research study among 10000 consumers and co-workers in Europe, China and the United States. The main findings[90] have been that over 70% of consumers surveyed care about sustainability, a significant proportion of consumers (35%) feel they could do more to purchase environmentally friendly products but cost is seen as a barrier for some (20%). Finally, customers would like retailers to prioritize sustainability issues, such as renewable energy, product durability and sustainable wood.

3.6. Conclusions

The market report outlines the following key characteristics of the EU furniture sector:
The EU-27 furniture production covers over 20% of the world total, being Italy and Germany the third and fourth major producers over the world, after China and the United States. More than half (55%) of the world furniture production takes place in middle and low income countries.

The stagnation in production will continue in 2013 with the exception of Eastern Europe and Scandinavian countries. Central European countries and the United Kingdom will remain stable, while southern countries, especially Spain and Italy, will further slowdown.
The most common material used in the furniture sector is wood (56% of the pieces of furniture produced in the EU 27 in 2011 are based on wood, which represent 56% of the production value). Metal is the second material most commonly used in the furniture industry (12% of items produced and 17% of the production value), followed by plastic (6% of items produced and 1% of the

production value) and other materials (1% of items produced and negligible production value) like bamboo, cannier, osier, glass. The remaining 25% represents materials which are not specified within the PRODCOM database.

18% of the pieces of furniture manufactured in 2011 in the EU-27 are composed of wooden furniture used in dining rooms, living rooms and bedrooms (20% by value). Other important production subsectors are kitchen furniture (15% by number, 18% by value), non-upholstered seats (14% by number, 8% by value), office furniture (9% by number, 12% by value), upholstered seats (8% by number, 15% by value) mattress supports (3% by number, 2% by value) and wooden furniture for shops (2% by number, 6% by value). About 31% is represented by unspecified furniture (19% by value).
The total furniture imports and exports in the EU27 area significantly declined in the period between 2008 and 2009. However, signs of recovering imports were observed in 2011. The largest European furniture exporters are Italy and Germany (42% of total EU27), while the largest importer is Germany (21% of total EU27). China is the major supplier to the EU27 (55.4 % of EU imports).

New opportunities will appear for furniture exporters due to an increasing demand in emerging countries. However import taxes can hamper such a development.

The competition from Asia, and most importantly China, is intensifying, and the pressure on prices is high.

Although wood is the most common material used, the pieces of furniture also contain other materials. The requirement of 90% content by weight of wood or wooden-based material is considered too restrictive by the manufacturers.

Based on the segmentation of the furniture market, it is considered reasonable to widen the scope of the EU Ecolabel criteria in order to cover a much broader share of the furniture market and to respond better to the expectations of the potential licence holders. The product group shall include furniture based on wood, metal, plastic and other materials (e.g. bamboo, cannier, osier). Furniture can also contain other components made, for instance, of textiles, glass or stone.

The scope of the EU Ecolabel criteria should be extended to cover furniture in general, not only wooden furniture. The current market context is favorable to host Ecolabel products. Companies gradually understand that consumers want to buy products that respect the environment. Issues concerning sustainability and environmentally-friendly design are becoming a very important part of the furniture design and production process. However, to achieve a significant impact, the consumers must be well informed to understand what the Ecolabel represents.

The uptake of EU core GPP criteria varies across countries. For the period 2009-2010, Denmark was the top performer as regards the inclusion of all GPP core criteria, with a share of 50%, followed by France (44%) and Belgium (40%). Only 14% of the furniture contracts respond to EU core GPP criteria, thus not meeting the target of 50% set at the EU level by 2010.

4. LCA SCREENING

When the existing criteria of wooden furniture were set (2008)[91] several environmental studies were analysed. From that analysis it resulted that the main environmental issues of relevance for furniture are use of energy and sourcing of wood.

Besides Key environmental impacts were identified for the definition of GPP criteria[92]:

- Loss of biodiversity and soil erosion and degradation, as a result of unsustainable forest management and illegal logging;
- Landscape impact from mining activities;
- Consumption of non-renewable resources such as metals and fossil hydrocarbons for energy and material production;
- Water and energy consumption for the production of several materials;
- Use and release of hazardous substances during production, use and end-of-life;
- Use of organic solvents and further generation of VOC emissions;
- Packaging;
- Early replacement of furniture due to a lack of reparability options, low durability, bad ergonomics or unsatisfactory fit for use.

For the current revision of the EU Ecolabel and GPP criteria, a comprehensive review of available Life Cycle Assessment (LCA) studies for furniture products has been done. Life Cycle Assessment studies allow the identification of potential environmental impacts of furniture products along all life cycle stages. This analysis in particular aims at identifying main envrionmental areas of concern and lifecycle hot-spots for the products within the scope of this revision and at estimating environmental improvement potential of measures applicable in different lifecycle stages.

A review of all LCA covering both wood and non-wood furniture (made of other materials) has been done. The goal of the LCA screening was to select those studies that comply with methodological and quality standards in order to establish a robust basis for the criteria revision process.

This screening consisted in the collection of all available literature and the further selection of studies through a set of criteria covering issues as methodology followed and relevance of scope, environmental indicators considered and outcomes of the assessment. Main results and outcomes were analysed carefully in order to draw common conclusions for this product group.

The literature is abundant of studies that deal with the LCA of furniture or with issues related to the furniture sector. Research has focused on studies of furniture made of different materials in order to substantiate the potential extension of the scope to other types of furniture.Studies refer to the main materials used in furniture: wood and wood-based panels; metals and plastics. Some other components such as glass, textiles and foam materials are also included within the scope of some studies.

4.1. Number and type of publications / lca studies analysed

From a preliminary review of the literature, 109 documents of potential relevance have been found and analysed:

- 13 Product Category Rules (PCR)
- 35 Environmental Product Declarations (EPD)
- 61 studies potentially related to LCA of furniture.

The information gathered includes:

- Papers and reports on the environmental performance of different pieces of furniture;

- Papers and reports focused on specific lifecycle stages (e.g. forestry, coating, finishings, end of life);
- Environmental Product Declarations and PCRs;
- Eco-design or sectoral guidelines based on LCA approaches.

All the scope of these studies covers: upholstered and not upholstered chairs, desks, tables, wardrobes/cabinets, kitchen furniture, bedroom furniture and wood panels. The analysed pieces of furniture are generally based on wood, wooden-based materials, metals (aluminium and steel) and plastics. Regarding the application, a big part of the studies refer to office and indoor domestic furniture.

4.1.1. Product Category Rules and Environmental Product Declarations (EPDs) for furniture.

Thirteen Product Category Rules documents have been found for furniture category belonging to different international EPD schemes. Complete EPDs have been found for 35 product s on the market, with some of them referring to different design options *(See APPENDIX II. Full LCA screening data and for the full list of PCRs (Table 45) and EPDs (Table 46)).*

30 EPDs refer to chairs and tables. Apart from one "cradle-to-gate" EPD for a chair, 29 EPDs state to cover all life cycle of products from "cradle to grave". Nevertheless, only 20 of these 29 EPDs takes into account for maintenance and cleaning of the product during the use phase and only 16 EPDs consider impacts from end-of-life. This exclusion is justified by the fact that these stages have low contribution to the overall impact and they are out of the control of the company.

For panels, the five EPDs have a scope from cradle-to-grave, but use stage is almost completely excluded because considered to present no significant impacts. Only the emission of formaldehyde during use stage is detailed in EPDs. The end-of-life scenario is valorisation in a biomass power plant with energy recovery for all EPDs.

4.1.2. LCA and environmental studies

61 studies potentially related to the LCA of furniture have been found in the literature. Most of the LCA studies are developed in accordance with the ISO 14040 guidelines. Nevertheless, not all of them are complete LCA studies referring to real case studies. Some of the studies, indeed, present a more theoretical approach, sometimes focusing on specific issues such as allocation. There are few studies that do not analyse furniture but focus on the production of materials or on specific processes, such as forestry, surface coatings or recycling.

The majority of LCA studies are attributional LCA, since they quantify the environmental impacts generated during the life cycle of a single piece of furniture without taking into account for rebound effects. Nevertheless, a consequential approach has been applied in some studies, for instance, in order to evaluate the consequences associated with reuse and remanufacturing, with the location of components manufacturing, with the content of recycled material or with the application of different coating processes, among others.

The studies have been classified in different categories, according to the type of furniture/material and the parameter assessed *(See the complete list of studies in APPENDIX II. Full LCA screening data and in Table 47).*

4.2. Screening of the quality of LCA studies

An analysis of the quality and the applicability of the above mentioned LCA and environmental studies have been carried out. A general methodology was defined for the LCA screening in order to select the LCA studies and gather the information that would be used in the technical analysis. Five steps have been followed:

Step 1: Preliminary identification of key environmental issues
A set of key environmental indicators to focus on were preliminarily identified based on:

1. PCRs available for this product group;
2. Preliminary screening of studies where impacts have been normalised and other relevant documents providing scientific basis for the selection of indicators (for further details see section *4.2.1 Preliminary identification of key environmental* issues*.*

Step 2: Screening of studies:

- Studies that do not satisfy minimal cut-off requirements (scope, impacts, outcomes) were disregarded;
- A scoring system was used to evaluate the quality of the studies that passed the first level of screening. An overall score was calculated based on 6 parameters: scope, data, impacts, outcomes, robustness and review of the study (see table below). A score from 1 to 5 was assigned to each parameter *(See*

Table 48 *for the detailed cut-off and scoring criteria in APPENDIX II. Full LCA screening data and tables).*

- Quality of the studies was considered satisfactory when the overall score was higher than 15. Studies were ranked based on the overall score obtained.

Step 3: Review of steps 1 and 2

- Based on the outcomes of step 2, it was checked that key environmental areas were correctly identified at step 1.

Step 4: Findings related to the key environmental issues identified

- Outcomes from studies of satisfactory quality were grouped by product analysed and by key environmental indicators. These studies allowed gaining relevant information for one or more environmental areas.

Step 5: Filling information gaps

Some of the disregarded studies could be however analysed if they allow gaining information on other specific issues of relevance (e.g. hazard materials).

Additional research would be necessary to fill any potential gap of information.

4.2.1. Preliminary identification of key environmental issues

In a first stage of the screening, a set of key environmental indicators of relevance for this product group have been identified based on the observation of relevant documents of reference, available PCRs for this product group and studies where impacts have been normalized.

Recommendations on broadness and appropriateness of impact assessment metrics

References for the evaluation of broadness and appropriateness of impact assessment metrics have been defined, for instance, in the Product Environmental Footprint (PEF) Guide[93]. The document proposes a set of 14 environmental impact categories to take into account to perform a coherent life cycle assessment of a product. Recommended impact categories and related assessment methods are provided in accordance with ILCD Handbook[96] (see more information on impact methods in section 4.2.2):

Table 17. Categories and impact methods recommended by the PEF guidelines.

EF Impact Category	PEF Impact Assessment Model
1.Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.
2.Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.
3.Ecotoxicity for aquatic fresh water	USEtox model
4.Human Toxicity - cancer effects	USEtox model
5.Human Toxicity – non-cancer effects	USEtox model
6.Particulate Matter/Respiratory Inorganics	RiskPoll model
7.Ionising Radiation – human health effects	Human Health effect model
8.Photochemical Ozone Formation	LOTOS-EUROS model

9.Acidification	Acumulated Exceedance model
10.Eutrophication – terrestrial	Acumulated Exceedance model
11.Eutrophication – aquatic	EUTREND mode
12.Resource Depletion – water	Swiss Ecoscarcity model
13.Resource Depletion – mineral, fossil	CML2002 model
14.Land Transformation	Soil Organic Matter (SOM) model

The PEF guide also indicates that, depending on the product system and on the intended application, it is possible to narrow the number of impact categories considered. Such exclusions should be supported for instance by: international consensus processes; previous studies of similar systems; Product Categories Rule from other initiatives/ schemes; normalization of results.

<u>Analysis of Product Category Rules (PCRs) documents for furniture products</u>

In order to select a set of key indicators for this product group, PCRs for furniture and related products as identified in section 4.1.1have been analysed.

All PCRs documents[214,215,216,217,218,219,220,221,222,223,224,225,226] refer to some common impact categories, whose quantification must be shown in EPDs compulsorily. All PCRs prescribe the use of the IPCC method for the assessment of the impact on climate change, and the CML 2001 method for the characterization of other impact categories, as indicated in Table 18. Besides these five impact categories, other specific indicators are asked for some furniture products groups. All PCRs also ask to provide data on the use of resources as a flow indicator.

Table 18: Methods for the categorization of impact categories

Information to provide from PCRs		Method	Unit of measure
Impact categories common for all PCRs	Greenhouse warming potential (GWP100 years)	IPCC	kg CO_2 equiv
	Ozone depletion potential (ODP)	CML 2001	kg CFC 11 equiv
	Acidification potential (AP)	CML 2001	kg SO_2 equiv
	Eutrophication potential (EP)	CML 2001	kg PO_4 equiv
	Photochemical ozone creation potential (POCP)	CML 2001	kg C_2H_4 equiv
Impact categories specific for some product group	Heavy metals[222]	EcoIndicator 95	kg Pb-eq.
	Depletion of abiotic minerals and resources (Abiotic Depletion Potential, ADP) [224]	CML 2001	kg Antimony eq.
	Human toxicity potential (HTP)[225]	CML 2001	kg DCB-eq.
Information related to the consumption of resources	Non-renewable resources: - material resources - energy resources	-	 kg MJ
	Renewable resources: - material resources - energy resources	-	 kg MJ
	Water use (including direct and indirect water consumption)	-	L

<u>Normalisation results from LCA studies</u>

Results of some case studies were normalized to identify the impact categories providing a more significant contribution within the respective environmental issue of concern.

In a French study that ADEME carried-out preliminarily to the establishment of product category rules and the application of product policy tools in the frameword of the Grenelle law for bed mattresses, upholstered seats, wood furniture[94], normalisation of the results was carried out using an average of French and European normalization methods (Ecobilan/Wisard 2002[95] and CML 2000, respectively).

For wood furniture it was found difficult to identify impact categories within which contributions were relatively higher. Environmental issues of higher concern could be: production of hazardous waste, terrestrial toxicity, ozone depletion, photochemical ozone creation. However, the results obtained seem indeed to vary considerably between the case studies analysed. What can be observed is that the relative contribution is much less relevant for water consumption, aquatic toxicity and human toxicity.

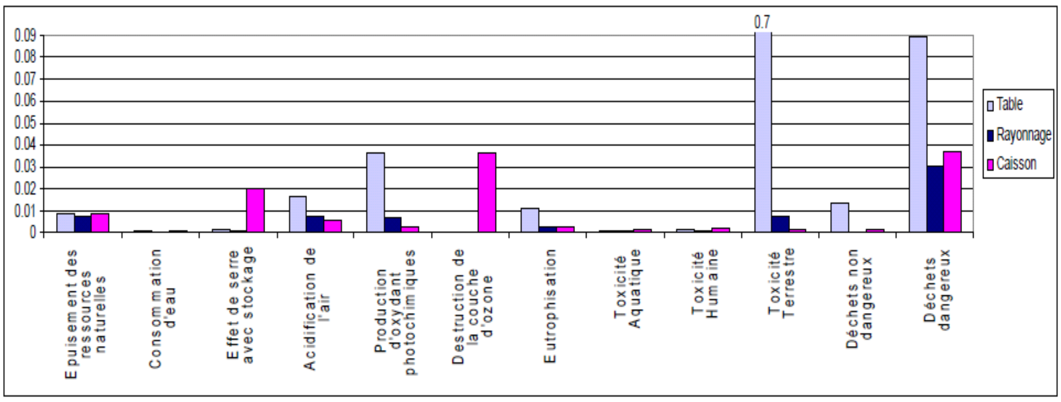


Figure 29. Normalised results for 3 wood furniture studies (different functional unit).

For upholstered seats, four environmental indicators appear less relevant: ozone depletion, aquatic toxicity, human toxicity and hazardous waste. However, it must be remarked that normalization does not allow itself to assess the importance of impact categories in absolute terms.

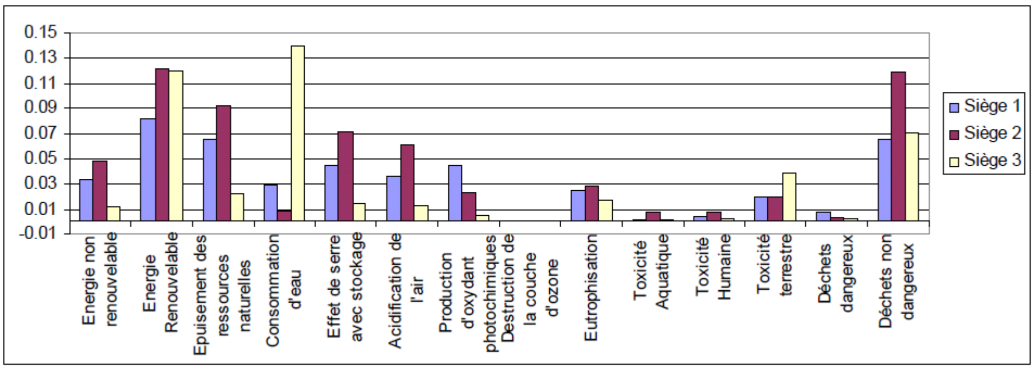


Figure 30. Normalised results for 3 upholstered chairs studied

With the results of normalisation, the study proposes a set of indicators for each product group according to the following criteria:
- Some flow indicators are excluded because not expressing directly the characterization of an impact category (e.g. energy consumption, water or waste generation).
- Some impact categories for which there is not a scientific consensus on impact models is also excluded (e.g. toxicity categories)

Table 19. Key environmental indicators identified for furniture products according to the study by ADEME

Impact indicator	**Wood furniture**	**Upholstered seats**
Natural resources depletion	X	X
Climate change	X	X
Acidification	X	X
Eutrophication		X
Photochemical ozone formation	X	X

However, it must be remarked that the results of normalisation only allow understanding for which categories the contributions to the overall impacts of a geographic area are higher, without indicating the general concern related to a specific environmental issue.

An LCA study of wooden desk for schools in Mexico[112], performed normalization to compare the relative scale of each of the impacts associated to the production of the school desk. Each impact category was divided by the normalization factors provided within the CML Baseline 2000 methods and referred to the global estimations for 1995. The normalised values indicate that the impact categories contributing mostly to the impacts on a global scale are terrestrial ecotoxicity, abiotic resource depletion and global warming.

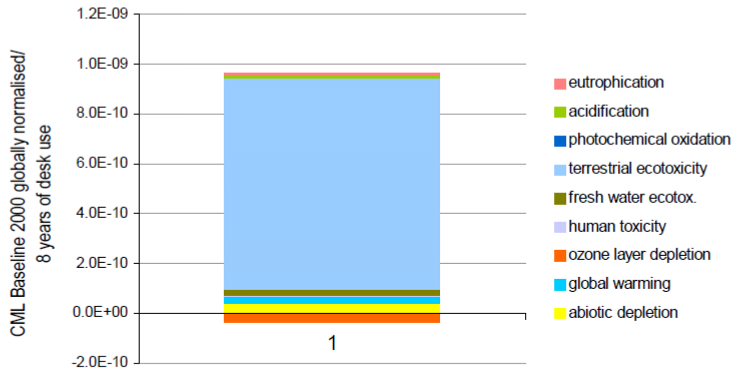


Figure 31. Total normalized impacts of desk per impacts category

<u>Selected list of key environmental indicators</u>

On the basis of the analysis done, it is considered that the key impacts categories of reference for assessing the environmental impact of furniture products in the present study should be:

1. Greenhouse warming potential
2. Ozone depletion potential
3. Acidification potential
4. Photochemical ozone creation potential
5. Eutrophication potential
    a. terrestrial
    b. aquatic

It must be noted that the eutrophication has been split into "terrestrial" and "aquatic". This is because the evaluation of this impact category differs based on the assessment method considered. For instance, PEF guide and ILCD handbook recommend to evaluate terrestrial and and aquatic eutrophication separately. Nevertheless, commonly used impact assessment methods consider these two categories together in a single impact category (as in the case of CML or ReCiPe).

Depletion of abiotic resources also shows relevant contribution for the furniture product group both in studies where normalisation has been performed and in PCRs. Nevertheless, this is not considered here as a key environmental indicator because reporting consumption of resources is less frequent for this product group and usually only material flows are reported.

4.2.2. Screening of LCA studies of relevance for the revision process

LCA studies have been screened in order to identify those that satisfy minimal requirements for quality and robustness and to select and rank the most relevant ones. The evaluation has concerned 61 studies and it has been performed in two steps. As a general rule, the 35 EPDs are not analysed through this scoring methodology, since they are verified studies and document, and they all comply the requirements of Product Category Rules. Nevertheless, available LCA reports supporting the development of some EPDs have been considered in the screening.

1) Minimal cut-off requirements have been set for:

- scope (functional unit properly defined and relevant for this revision, scope coherent with goal analysis, respect of ISO 14040 standard),
- impact assessment (satisfactory broadness or quality of the indicator(s) considered in the analysis) and
- outcomes (relevant and applicable outcomes).

Studies not passing these criteria have not been used to analyse the lifecycle hot-spots of furniture products. Nevertheless, it may be that some of the disregarded studies will be useful for dealing with some issues relevant for the revision process (e.g. hazardous substances, forestry, waste treatment).

From the 61 studies found:

- 15 have been considered to satisfy the minimal cut-off criteria set,
- 12 have not passed the cut-off criteria but could be of relevance for other issues to deal along the revision process
- 34 have been considered to have limited or no application in the revision process.

2) Quality of the studies passing the first level of screening has been evaluated through a scoring system. Six parameters have been taken into account: scope, data, impact assessment, outcomes, robustness of the study and critical review.

For each parameter a score from 1 to 5 has been assigned as described in the table above. Quality of the studies has been considered satisfactory when the sum of the scores is higher than 15. 13 out of 15 studies have obtained a score higher than 15, as detailed later (see section4.2.4).

<u>Quality of indicators/impact categories</u>

The Recommendations of the ILCD Handbook[96] have been consulted in order to evaluate which assessment methods are more appropriate to quantify impacts for each of the environmental categories identified in section 4.2.1. Recommendations also provide an evaluation of alternative methods. Impacts assessment methods are classified from A to E, where A represents the best in class methods. Classification criteria focus on scientific aspects and stakeholder acceptance.

Scientific criteria are**:**

1. Completeness of scope;
2. Environmental relevance;
3. Scientific robustness and certainty;
4. Documentation, transparency and reproducibility;
5. Applicability;
6. Overall scientific acceptance (based on the other single scientific criteria)

A criterion referring to **stakeholder acceptance** is also provided since degree of stakeholder acceptance and suitability for communication in a business and policy contexts.
A-to-E classification is based on “expert judgement” including consideration of the importance of different criteria and sub criteria. For each criterion scoping is:
A: Full compliance
B: Compliance in all essential aspects
C: Compliance in some aspects
D: Little compliance
E: No compliance

Final method recommendations have been made in the ILCD Handbook based on the criteria presented. A default method was selected as recommendable for each impact category and classified according to its maturity and appropriateness (level, I, II, III, interim).

In the present study, the **overall scientific acceptance** has been considered the main parameter of evaluation for impact assessment methods. The cut-off criteria for this screening is that the study must consider at least one indicator of interest (with respect to the impact categories identified in section 4.2.1) and all the indicators of interest used are evaluated as at least C (average class) according to Recommendations of the ILCD Handbook.

For Eutrophication, many characterisation models analysed in the ILCD document treat separately terrestrial and aquatic systems, addressing one or both of them. Based on this, the pre-selection of characterisation models for eutrophication is shown separately for the two sub categories terrestrial and aquatic eutrophication. However, most impact methods and studies expressed terrestrial and aquatic eutrophication as a single category expressed as total eutrophication.

In *APPENDIX II. Full LCA screening data and tables* you can find the detailed list of methods evaluated. The table shows the evaluation of different assessment methods (from A to E, referred to overall scientific acceptation) and the default method recommended for each of the impact categories identified before.

4.2.3. Selection of LCA studies

Each of the above mentioned studies has been analysed in order to check if cut-off requirements on scope, impact assessment and outcomes are matched (√) or not (**x**). The results of the assessment are reported in the following table.

Table 20. Evaluation of environmental studies gathered according to cut-off criteria

Category		Number/type of papers	References COLOUR LEGEND: GREEN (selected study); ORANGE (disregarded study but could be useful); RED (disregarded study)	Cut-off scope	Cut-off impacts	Cut-off outcome	Reasons for exclusion
Furniture made of wood	Panels	1 report laminate	Cho, S., Huang, J. An Investigation into Sustainable Building Materials – Laminate Wood. 2010	X	X	X	Building applications. Not a consistent / complete LCA (approach) as defined in ISO 14040 LCA
		1 paper hardboard	González-García, S., Feijoo, G., Heathcote, C., Kandelbauer, A., Moreira, T. Environmental assessment of green hardboard production coupled with a laccase activated syste. Journal of Cleaner Production 19 (2011) 445e453	√	√	√	
		1 report MDF recycling	Mitchell, A., Stevens, G. Life Cycle Assessment of Closed Loop MDF Recycling: Microrelease Trial. 2009	√	√	√	
		1 paper MDF	Rivela B, Moreira MT, Feijoo G (2007): Life Cycle Inventory of Medium Density Fibreboard. Int J LCA 12 (3) 143–150	X	X	√	Cradle-to-gate for a very specific product process. Endpoint indicators
		1 report MDF	Wilson, J.B., Medium Density Fiberboard (MDF): A Life-Cycle Inventory of Manufacturing Panels from Resource through Product, 2008	X	X	X	Only Life Cycle Inventory Data
	Wood products	1 paper childhood set	González-García, S. , Raúl García Lozano, R., Moreira T., Gabarrell, X., Rieradevall, J., Feijoo, G., Murphy, R.J. Eco-innovation of a wooden childhood furniture set: An example of environmental solutions in the wood sector. Science of the Total Environment 426 (2012) 318–326	√	√	√	
		1 report desk (Italy)	IGEAM - Unione Industriali Pordenone. Scrivania - MArtex LCA – VALUTAZIONE DEL CICLO DI VITA, 2010	√	√	√	
		1 report Workplace: (Italy)	IGEAM - Unione Industriali Pordenone. Postazione di Lavoro Alea LCA – VALUTAZIONE DEL CICLO DI VITA, 2010	√	√	√	
		1 report wardrobe (Italy)	IGEAM - Unione Industriali Pordenone. Armadio Mascagni – Dall'Agnese LCA – VALUTAZIONE DEL CICLO DI VITA, 2010	√	√	√	
		1 report wardrobe (Italy)	IGEAM - Unione Industriali Pordenone. Armadio – Martex LCA – VALUTAZIONE DEL CICLO DI VITA, 2010	√	√	√	
		1 report kitchen (Italy)	IGEAM - Unione Industriali Pordenone. Cucina Samoa – Copat LCA – VALUTAZIONE DEL CICLO DI VITA	√	√	√	
		1 report door (Italy)	IGEAM - Unione Industriali Pordenone. Ante – Acop LCA – VALUTAZIONE DEL CICLO DI VITA	X	√	X	Door is out of the scope of the study
		1 report. School desk	UNEP SETAC. Life Cycle Assessment. A product-oriented method for sustainability analysisTraining Manual. 2008	√	√	√	
	Forestry	4 papers of forestry in	ESHUN J. F., POTTING J. and LEEMANS R. Sustainability of forestry and timber industry in Ghana. International Forestry Review Vol.12(4), 2010	X	X	X	Not a consistent / complete LCA approach as defined in ISO 14040.

		Ghana					Generic sustainability assessment on forestry in Ghana
			Eshun, J.F., Potting, J. , Leemans, R. LCA of the timber sector in Ghana: preliminary life cycle impact assessment (LCIA). Int J Life Cycle Assess (2011) 16:625–638	√	√	x	Specific to forestry in Ghana. Results no applicable to revision process
			Eshun, J.F., Potting, J. , Leemans, R. Inventory analysis of the timber industry in Ghana. Int J Life Cycle Assess DOI 10.1007/s11367-010-0207-0	x	x	x	Only LCI data
			Eshun, J.F., Potting, J. , Leemans, R. Wood waste minimization in the timber sector of Ghana: a systems approach to reduce environmental impact. JCP, 2012	x	x	x	Focused only on waste minimisation
		1 report on forestry	European forest institute. Energy, carbon and other material flows in the Life Cycle Assessment of Forestry and forest products. 2001	x	x	x	Review of LCAs for forestry operations. Theoretical study
		1 report forestry	LCA a challenge for forestry and forest products. 1995	x	x	x	Not LCA. Proceeding of forestry conference. Theoretical papers.
		1 report of forestry in Australia	Tucker, S.N. , Tharumarajah, A.,May, B. , England, J., , K. Paul, K., Hall, M., Mitchell, P., Rouwette, R., Seo, S., Syme, M. Life Cycle Inventory of Australian Forestry and Wood Products. 2009	x	x	x	Only LCI. Referring to Australia
	Preservatives	1 report / paper	Bolin, C.A., Smith, S.T. Life Cycle Assessment Procedures and Findings for ACQ-Treated Lumber	√	√	x	Very specific study. Focused on Alkaline copper quaternary (ACQ) preservative used for decking woods.
	General	1 report (Grenelle)	ADEME (Agence de l'Envrinnement et de la Maltreise de l'Energie). Rapport d'étude PROPILAE – V1 – 2010.	√	√	√	
		1 report wood applications	Vogtländer, J:G:, Life Cycle Assessment of Accoya® Wood and its application,	x	√	x	Complete LCA, but specific for building applications (window, deck, bridge) out of the scope
Furniture made of metal		2 reports / papers	Conway, C.C., Steelcase Green Product Development: An Early Stage Life Cycle Analysis Tool and Methodology. 2008	x	x	x	Concerning the development of a tool for simplified LCAs.
			Dietz, B.A., Life cycle assessment of office furniture products, 2005	√	x	√	Preliminary study of the LCA from the company Steelcase.
Furniture made of mixed materials		8 reports / papers	Center for Sustainable Systems. University of Michigan. Life-Cycle Assessment of Office Furniture Products. Final report on the study of three Steelcase office furniture. 2006	√	√	√	
			Forest & Wood Products Research & Development Corporation. Review of the Environmental Impact of Wood Compared with Alternative Products Used in the Production of Furniture. 2003	x	x	x	Review of LCAs. Other applications than furniture.
			Indian Centre for Plastics in the Environment (ICPE). SUMMARY REPORT FOR LIFE CYCLE ASSESSMENT OF FURNITURE	√	√	√	
			Kebbouche, Z., Tairi, A., Cherifi, A., Impact study and valorization of waste of metal furniture by the LCA method.	x	x	√	Focused on metal framework (office).

		Russell, S.N., Allwood, J.M. *Environmental evaluation of localising production as a strategy for sustainable development: a case study of two consumer goods in Jamaica.* Journal of Cleaner Production 16 (2008) 1327e1338	√	X	√	Only assessing energy consumption (not other impacts). Useful information for energy consumption and Life Cycle Costing. It does not calculate any of key environmental impacts selected as cut-off.
		Sahni, S., Boustani, A.,Gutowski, T.,, Graves, S. Furniture Remanufacturing and Energy Savings. 2010	X	X	√	Inventory data from Steelcase study. Useful information for energy consumption and Life Cycle Costing. It does not calculate any of key environmental impacts selected as cut-off.
		Suttie, E., Briefing note for Forestry Commission An update on Wood Plastic Composites (WPC). 2007	X	X	X	Not LCA.
		Université M'Hamed Bougara Bourmerdès.Impact study and valorisation of waste of metal furniture by LCA method	X	X	X	Simplied LCA study. Focused on end-of-life. Qualitative results
	5 reports /papers chairs	DONATI environmental awareness. EPD nr S-P-00154; EPD nr S-P-00155 EPD nr S-P-00241; EPD nr S-P-00242. www.donati.eu/ambiente	√	√	√	LCA report for the elaboration of EPD
		Gamage, G. B., Boyle, C. , McLaren S.J., McLaren, J. Life cycle assessment of commercial furniture: a case study of Formway LIFE chair. Int J Life Cycle Assess (2008) 13:401–411	√	√	√	
		Michelsen, O., Fet, A.M., Dahlsrud, A. Eco-efficiency in extended supply chains: A case study of furniture production. Journal of Environmental Management 79 (2006) 290–297	X	X	X	Focused on the roal of suppliers. Not LCA results
		Michelsen, O. Eco-efficiency in redesigned extended supply chains; furniture as an example. 2007	X	√	X	Theoretical study
		Michelsen, O. Investigation of relationships in a supply chain in order to improve environmental performance. 2007	X	X	√	Screening LCA referring only to production. Some useful information provided for the supply-chain. Assessment based on the single score of Ecoindicator'99.
End of life (including reuse)	11 reports / papers	Critchlow, J. End of life furniture sustainability. 2010	X	X	X	Not a LCA study. Focused on upholstery furniture in Australia.
		Curran, A., Williams, I.B. The role of furniture and appliance re-use organisations in England and Wales. 2009	X	X	X	Paper focused on the analysis of Third sector organisations of reused furniture. No LCA results
		Hong Ren, H., Thesis, M. Plastic Waste Recycling and Greenhouse Gas Reduction Greenhouse. 2012	X	X	X	Study on recycling plastics in Copenhagen. Very narrow scope. No LCA results
		Hopewell, J., Dvorak, R.,Kosior, E. Plastics recycling: challenges and	X	X	X	Not a LCA study. Paper on plastic

		opportunities. Phil. Trans. R. Soc. B 2009 364, 2115-2126				recycling (general, no furniture)
		JUNGMEIERG, MERL A , McDARBY F , GALLIS C, HOHENTHAL C, PETERSEN AK, SPANOS K. End of Use and End of Life Aspects in LCA of Wood Products – Selection of Waste Management Options and LCA Integration	X	X	√	Not a LCA study. Some useful data on wood waste treatment in Europe (but not updated)
		Rivelaa, B., Moreira, T., Muñoz, I., Joan Rieradevall, J., Feijoo G. Life cycle assessment of wood wastes: A case study of ephemeral architecture. 2005	X	√	√	Wood waste use for MDF. Cradle to gate scope. Study focused on ephemeral architecture.
		Werner, F., Althaus, H-J., Richter, K. , Scholz, R.W. Post-Consumer Waste Wood in Attributive Product LCA. 2007	X	X	X	Theoretical study about allocation rules on wood materials
		WRAP. Benefits of Reuse Case Study: Domestic Furniture. 2011	X	X	√	Not a LCA study but useful because presenting environmental and social benefits due to reuse (CO2, resources and energy)
		WRAP. Benefits of Reuse Case Study: Office Furniture. 2011	X	X	√	Not a LCA but useful because presenting environmental and social benefits due to reuse (CO2, resources and energy)
		WRAP. A methodology for quantifying the environmental and economic impacts of reuse	X	X	X	Theoretical study
		Werner, F. Recycling of used wood - inclusion of end-of-life options in LCA.	X	X	X	Theoretical study
Temporary carbon storage	2 reports / papers	Brandão, M., Levasseur, A. Assessing Temporary Carbon Storage in Life Cycle Assessment and Carbon Footprinting. 2010	X	X	X	Theoretical study about carbon storage
		Perez-Garcia, J., Lippke, B., Comnick, J., Manriquez, C. An assessment of carbon pools, storage, and wood products market substitution using Life-Cycle analysis results.	X	X	X	Theoretical study only focusing on carbon storage
Hot spots identification	6 reports / papers	Andriola, L., Buonamici, R., Caropreso, G., Luciani, R., Masoni, P., Roman, R. Advances in Life Cycle Assessment and Environmental Management Systems: An Integrated-Approach Case Study for the Wood-Furniture Industry	X	X	X	Theoretical study
		Chaves, L.I. Design for sustainability: A methodological approach for the introduction of environmental requirements in the furniture sector. 2008	X	X	X	Theoretical study
		Liedtke, C., Rohn, H., Kuhndt, M.,Nickel, R. Applying Material Flow Accounting: Ecoauditing and Resource Management at the Kambium Furniture Workshop	X	X	X	Not a LCA study but a set of qualitative data provided for a EMAS audit in a furniture factory
		Pitcher, M. LCA IN FURNITURE RATING TOOLS - A USER S VIEW. 2010	X	X	X	Australian labels and Standards review. Theoretical analysis of the use of LCA in these labels.
		WRAP. A methodology for quantifying the environmental and economic impacts of reuse	X	X	X	Theoretical study

		Werner, F. Recycling of used wood - inclusion of end-of-life options in LCA.	X	X	X	Theoretical study
Health issues/Chemicals	3 reports / papers	Andersson, P., Simonson, M. Stripple, H. Fire safety of upholstered furniture, A Life-Cycle Assessment – Summary Report. 2003	√	√	X	Comparison of the environmental impact of using or not flame retardants in domestic upholstered furniture, taking account impact of accidental fires.
		Askham, C.,Hanssen, O.J., Gade, A.L. ,Nereng, G., Aaser, C.P., Christensen, P. Strategy tool trial for office furniture. Int J Life Cycle Assess (2012) 17:666–677 DOI 10.1007/s11367-012-0406-y	X	X	√	Not a LCA but useful comparison between EPDs and REACH assessment for seating solutions. Results suggested that product development should encompass both REACH information and LCA data to adopt a balanced view on environmental performance factors. Nevertheless, these two analysis do not show the same priorities rank.
		Pitcher, M. LCA Treatment of Human Health exemplified by formaldehyde within the furniture industry. 2005	√	X	X	Theoretical approach to include indoor emissions of formaldehyde into LCA models.
General guidelines	1guide with LCA approach	IHOBE. Sectoral Guide of Ecodesign. Furniture (Guías sectoriales de ecodiseño. Mobiliario). 2010.	√	√	√	

The analysis allowed understanding the relevance of the collected material for the criteria revision process. 15 out of 61studies have been assessed to satisfy the minimal cut-off criteria set. Nevertheless, some studies that have been excluded at this stage could become useful at along the revision process to address some specific issues (such as forestry, coating substances, end of life treatments). 12 studies that have not passed the cut-off criteria are considered to be potentially useful for the revision process (marked in orange in Table 20) whereas 34 studies seems to have low application for the revision process.

4.2.4.Qualitative scoring and summary of selected LCA studies

Quality of 15 LCA studies satisfying the presented quality cut-off criteria have been analysed comprehensively using the scoring criteria presented in the Section 4.2.2. Studies have been ordered by ranking overall score values and are presented in the tables below. Studies obtaining an overall score above 15 (13 out of 15) have been considered to present a satisfactory level of quality. Main outcomes and conclusions are detailed in the following summary data sheet for each study.

EPDs were not assessed through the scoring methodology and thus they are not included in this summary since the information reported is usually summarized and the lack of calculation details make difficult to analyse hot-spots and improvement options. Nevertheless, they still form an important source of information for some parts of this section and, more in general, for the entire technical analysis, as for the analysis of materials used in furniture and average composition (section4.3.2).

TOTAL SCORE		S_{SCOPE}= 5 S_{DATA}=3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ = 5 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1	**S_{TOTAL} =22**
1	***Item***	***Observation***	***Scoring***
1	**title**	Rapport d'étude PROPILAE (PROjet PILote pour l'Affichage Environnemental des produits d'ameublement)[94]	-
2	**authors**	ADEME. Agency of Environment and Energy (France)	-
3	**reference and year**	2010	-
4	**type of study**	LCA of each product according to ISO standards. The goal is to set the basis for the development of PCRs and the application of product policy tools for bed mattresses, upholstered chairs and wood furniture, in the framework of the Grenelle law (2010-788)	S_{SCOPE} = 5
5	**scope**	10 products: 3 bed mattresses, 1 bed frame, 3 couches, 1 kitchen, 1 table, 1 library	
6	**functional unit**	–Beds: Provide one place sleeping used daily for one year. –Couch: Provide 1 place seat, with at least 40 cm when the product is displayed for one year. –Kitchen cabinet: Provide 1 dm^3 storage for one year. –Table: Provide a useful surface for one year. Space minimum 60x40 cm^2 –Library: Not defined	
7	**system boundaries**	Cradle-to-grave All life cycle stages (raw materials, production and waste from production), distribution to retail, use, end-of-life) with the exclusion of: transport of workers, customers, R&D and marketing activities, impacts of selling and platforms of distribution, transport of waste.	
8	**assumptions (e.g. allocation)**	- Burdens due to manufacture of different furniture products allocated based on the mass of the units produced. - Benefits due to recycling evaluated as difference between impacts from recycling and impacts from primary materials substituted.	
9	**data sources and quality**	Primary data from 10 companies (French manufacturers). Secondary data: Ecoinvent 2.0, literature of professional associations of each product group. Software used for LCI is TEAM.	
	1. Raw materials	Primary data: Manufacturers for composition of each furniture and quantities and typology of materials (polyester, polyurethane, stell, board, furniture components, fabrics). Secondary/Generic data from sectorial associationsand Ecoinvent.	*3*
	2. Manufacturing	Primary data. Manufacturers.	*3*
	3. Distribution/transportation	Primary data from logistic services of companies. Ecoinvent 2.0 and AFNOR data for LCI data.	*3*
	4. Use phase	Simulations on maintenance scenarios.	-
	5. Packaging	Primary data on type of packaging used (PE, cardboard, polyester)for each furniture product. Ecoinvent 2.0 for LCI data.	*3*
	6. End of Life	Literature: French statistics from ADEME, Ecoinvent 2.0 for LCI data.	*3*
	TOTAL		S_{DATA} =*3*

10	**Impact assessment categories/methods**	•GWP: IPCC 2007 (classification A) •Ozone depletion potential (CML 2000) (classification A) • Acidification potential (CML 2000) (classification B) •Photochemical oxidant creation pot. (CML 2000) (classification B) •Eutrophication potential (CML 2000) (classification B) •Toxicity (CML 2000) (not considered as key indicator) •Ecotoxicity (CML 2000) (not considered as key indicator)	$S_{IMPACTS}$ =5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Hot spots and sensitive analysis for each product group. For upholstered chairs, the end-of-life (scenario combining recycling and disposal depending on the recyclability of each component) has relevant impacts for eutrophication (34%) (and toxicity (95-53%)) (due to lixiviation. For the rest of indicators, the production of raw materials is the most relevant stage (49% - 100% depending on the impact category). The materials providing highest contribution are: textiles, foaming materials and metal structures. Sensitive analysis was carried-out to understand the influence on the results due to: - i) Type of textile used and site of fabrication of textile/cover. It is showed that air acidification is the category most sensitive to transport, but the variation is low, in general, due to the low weight of cover. Regarding the type of textiles, comparing polyester, cotton and linen, linen has minor impacts than cotton (due to lower consumption of water and chemicals) and polyester (which has lower impacts than cotton, but higher impacts than linen due to the use of fuel). - ii) Maintenance of covers: one cleaning action (washing with electricity, detergent and water consumption) for timespan (10 years). Cleaning only increase by 0.5% the overall impact of all indicators. For wood furniture, main impacts are photochemical oxidants formation and ozone depletion, Even if not included in the scope of the present review, also human toxicitiy appears a relevant hot-spot because of the use of alkyde resins in finishing. Due to the presence of wood, raw materials have lower relative contribution (26% - 100% depending on the impact category), whereas manufacturing and transport stages have higher values. In manufacturing, finishing products cause relevant impacts on terrestrial toxicity and fossil energy. Ozone depletion is caused mainly for transport, and Teflon used in metal drawer guides	$S_{OUTCOMES}$ =5
12	**Strengths and weakness of the whole study, general comments**	Normalisation carried-out to choose relevant impact categories (see details in section 3.1). Sensitive analysis also performed. Useful outputs for products included within the scope of the present revision (upholstery chairs and wood furniture)	$S_{ROBUSTNESS}$ =3
13	**Subject to independent review?**	Official study (French Government). Elaborated by ADEME, reviewed by working group GT7 , with members of furniture sectors of France.	S_{REVIEW} = 1

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}= 3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=3	**S_{TOTAL} =20**

2	***Item***	***Observation***	***Scoring***
1	**title**	Eco-innovation of a wooden childhood furniture set: An example of environmental solutions in the wood sector [97]	-
2	**authors**	González-García, S., Raúl García Lozano, R., Moreira T., Gabarrell, X., Rieradevall, J., Feijoo, G., Murphy, R.J.	-
3	**reference and year**	Science of the Total Environment 426 (2012) 318–326	-
4	**type of study**	ISO 14040. LCA and Design for Ecodesign (DfE) combined.	S_{SCOPE} = 3
5	**scope**	Wooden childhood furniture set produced in Spain (baby cot convertible into a bed, a study desk and a bedside table) Furniture composition: Solid timber 2%, MDF 10%, Particleboard 86%, Zamak (screws) 0.16%, Stainless steel (screws) 0.08%, Stainless steel (rods), 0.46%, Stainless steel (guides) 0.75%, Chromium-plated tube 0.22%, PVC (edges and stoppers), 0.01%, Polyester (handle), 0.02%, PE (plugs), 0.05%, Glue 0.30%, Paint 0.08%	
6	**functional unit**	The functional unit selected corresponds to the supply of a wooden childhood furniture set, whose total weight is 173.9 kg	
7	**system boundaries**	Cradle-to-grave.Installation, maintenance and final disposal of the product were excluded from the assessment. Raw materials include raw wood, particleboard and MDF, metal structure and plastic components. Production includes assembling stage, finishing stage (painting) and packaging stage.	
8	**assumptions (e.g. allocation)**	Total electricity and heat consumption and packaging materials have been allocated between different products of the company based on their annual production in weight.	
9	**data sources and quality**	Primary data from company under study (Spain), average production data for year 2009. Ecoinvent, IDEMAT and literature (scientific papers on MDF and particleboards) for secondary data	
	1. Raw materials	MDF and particle boards from LCA literature, Metal materials data from IDEMAT database. Other materials like plastic pieces, paints, fabric, glass, social timber and wooden pallets from Ecoinvent,	*3*
	2. Manufacturing	Average annual data of the company (year 2009) for production processes: assembly, finishings and packaging. LCI data from Ecoinvent	*3*
	3. Distribution/transportation	Primary data: evaluation scenario according to transport routes of the company (truck and average distance). Final distribution of the product is performed by truck and an average transport distance. (264 t·km have been considered). LCI data from Ecoinvent. Sensitive analyses by changing diesel with biodiesel, and usining Euro V vehicles.	*3*

	4. Use phase	-	-
	5. Packaging	Primary information of types of packaging. Materials from Ecoinvent (cardboard and plastic pieces)	*3*
	6. End of Life	-	-
	TOTAL		S_{DATA} =*3*
10	**Impact assessment categories/methods**	CML 2 baseline 2000 V2.1. •global warming, (classification A) •ozone layer depletion, (classification A) •acidification, (classification B) •photochemical oxidant formation(classification B) •eutrophication, (classification B) •abiotic depletion, (not considered as key indicator) •human toxicity, (not considered as key indicator) •fresh water aquatic ecotoxicity, (not considered as key indicator) •marine aquatic ecotoxicity, (not considered as key indicator) •terrestrial ecotoxicity (not considered as key indicator)	$S_{IMPACTS}$ = 5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	According to this LCA, the main environmental hot-spots are: -the production of the wooden boards, which is the main component of the furniture set and which is the major contributor for abiotic depletion, acidification, eutrophication, ozone depletion, photochemical oxidation, human and eco-toxicity (45–68% of the total impacts, depending on the indicator considered). This is mainly due to the production of particleboard with high energy requirements and resins (for toxicity). Regarding GWP, 49% comes from the use of wooden materials followed by far by electricity consumption during manufacturing (21%). -The consumption of electricity during assembly is the second hot spot, contributing to 14–33% of the impacts. This is also influenced by the production mix considered. The Spanish grid was considered here, which depends considerably on fossil fuels. -Transport activities could also be important in terms of ODP (23% of contribution) due to tailpipe emissions from trucks. Several alternatives are proposed in DfE to achieve reductions of impacts in the short-medium period. These include: optimization of materials used, re-use of internal waste, minimization of energy use, use of renewable energy, limited amount of packaging materials, promotion of fuels with lower impact and prioritization of Euro V vehicles in transport. All in all, these measures could lead to decrease the environmental impacts by 14%.	$S_{OUTCOMES}$ = 3
12	**Strengths and weakness of the whole study, general comments**	Two environmental approaches were combined in order to propose improvement alternatives: Life Cycle Assessment (LCA) and Design for Environment (DfE).	$S_{ROBUSTNESS}$ =3
13	**Subject to independent review?**	Publication in a peer-reviewed journal	S_{REVIEW} = 3

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}=2.6 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =5 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} = 19.6**
3	***Item***	***Observation***	***Scoring***
1	**title**	Sectorial Guide of Ecodesign. Furniture[98]	-
2	**authors**	IHOBE.	-
3	**reference and year**	2010 (http://www.ihobe.net/Publicaciones/Ficha.aspx?IdMenu=750e07f4-11a4-40da-840c-0590b91bc032&Cod=%7B03DED2C8-31B3-4EFF-9DF1-9B424A30B508%7D)	-
4	**type of study**	Attributional LCA for 10 products. Consequential approach for ecodesign measures and real case studies.	S_{SCOPE} = 3
5	**scope**	Basque Country (Spain). 10 representative products: armchair, office chair, operational office chair, metal drawers, nightstand, office wheel chair, office divider panel, operational table office, showcase, side table, wooden wardrobe, armchair. Weight composition reported below: –Showcase: Aluminium 34%, Steel 34%, Glass 15%, Fibreboard panels 0,1%, PVC 1%, Ceramics 16% –Metal drawers: Steel 77%, Paint 18%, Polycarbonate (PC) 4% –Side table: Steel 62%, Glass 36%, Paint 3% –Office chair / operational office chair: Steel 48%, Wood 52%, Polyurethabe (PUR) 0,2% –Office wheel chair: PUR 10%, Polypropylene (PP) 26%, Wood 15%, Steel 32%, Polyamide (PA) 18% Wooden wardrobe / armchair: Wood 98%,PVC 1%, Brass 0,2%, Steel 1% –Nightstand: Wood 94%, Brass 3%, Steel 1%, PVC 2% –Chair: Wood 81%, PUR+Polyethylene (PE) 19% –Operational table office: Steel 58%, Fibreboard: 41%, PE: 1%, Other plastics: 0,4% –Office divider panel: ABS 0,5%, Steel 3%, Methacrylate 70%, Aluminium 27% –Armchair.: Wood 72%, PUR 11%, Textile 2%, Steel 16%	
6	**functional unit**	1 unit of furniture	
7	**system boundaries**	Cradle-to-grave Stages included: materials, manufacturing, distribution, use and end-of-life	
8	**assumptions (e.g. allocation)**	Only cleaning water considered for the use phase.	
9	**data sources and quality**	Primary data from industry, Ecoinvent 2.0 for LCI data	
	1. Raw materials	Ecoinvent 2.0	*3*
	2. Manufacturing	primary data for Basque companies representative of furniture sector, Ecoinvent 2.0 for LCI data	*3*

	3. Distribution/transportation	Primary data from sectorial reports from the Spanish Manufacturers and Exporters of Furniture (ANIEME) and the Technological Institute of Furniture (AIDIMA). Ecoinvent 2.0 for LCI data	*3*
	4. Use phase	-	-
	5. Packaging	primary data, Ecoinvent 2.0	*3*
	6. End of Life	Ecoinvent 2.0	*1*
	TOTAL		S_{DATA} *2.6*
10	**Impact assessment categories/methods**	CML 2001: –Global Warming Potential. (classification A) –Acidification. Potential (classification A) –Ozone Depletion Potential. (classification B) –Photochemical Ozone Formation (classification B) –Eutrophication Potential. (classification B) –Human Toxicity (not considered as key indicator) –Ecotoxicity (not considered as key indicator) –Abiotic resources depletion. (not considered as key indicator) Eco-indicator'99 Single score (no information on metrics, cultural perspective, and normalisation factors considered)	$S_{IMPACTS}$ =5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Results split by type of furniture. Hot spots identification: in all products, main environmental impacts are due to the production of materials. Contributing from 72% to 90% of the lifecycle impacts. Processing of materials (assembling) contributed from 6% to 20%. Transport of the final product contributed from 1% to 15%. Use stage has a percentage of impact no significant. End-of-life has a contribution from 1% to 4%. Some ecodesign proposals and practical cases are also provided. Some strategies explored are: selection of materials with low impacts, reduction of materials, selection of low-impact production technologies, optimization of distribution and end-of-life. Several information of ecodesign measures are also reported (more information in section 4.3.5)	$S_{OUTCOMES}$ = 5
12	**Strengths and weakness of the whole study, general comments**	Simplified LCAs, but robust methodology on the selection of representative case studies for furniture to which apply ecodesign measures.	$S_{ROBUSTNESS}$ = 3
13	**Subject to independent review?**	Official Source. No review	S_{REVIEW} =1
TOTAL SCORE	S_{SCOPE}=3	S_{DATA}=3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=5	**S_{TOTAL} = 19**
4	***Item***	***Observation***	***Scoring***
1	**title**	*Life Cycle Assessment of Closed Loop MDF Recycling: Microrelease Trial*[99]	-
2	**authors**	Mitchell, A., Stevens, G.	-
3	**reference and year**	http://www.wrap.org.uk/sites/files/wrap/MDF%20LCA%20FINAL%20version.pdf, 2009	-
4	**type of study**	ISO 14044. Consequential LCA assessing production of virgin and recycled MDF (rMDF) boards and waste-scenarios for MDF wastes (recycling, incineration). Sensitive analysis on resin content, transport distance, materials sourcing (total 13 scenarios).	S_{SCOPE} = 1
5	Scope	MDF panel, domestic, Germany This study focuses on the manufacture of MDF boards, including the waste generated from the process and the reintroduction of recovered fibres into the MDF manufacture.	
6	**functional unit**	A production unit of 1 tonne of MDF and rMDF (recycled fibres in 10% and 20%), where rMDF has been shown to be a technically comparable product in terms its mechanical properties	
7	**system boundaries**	Cradle-to-gate (close loop for production wastes) System includes the MDF manufacturing process: raw materials supply (forestry), transport of materials, wood fibres production and board production. It includes waste generation by MDF production and proposed disposal routes, including reintroduction of recovered fibres. The study excludes transportation of finished board from the MDF plant to customers and activities related to the use of the MDF board in furniture.	
8	**assumptions (e.g. allocation)**	The main product is the wood panel, residual wood is obtained as by-product. Recycling of wood avoids gas combustion for heat generation and need of virgin fibres.	
9	**data sources and quality**	Primary data from a German company (year 2007-2008) for MDF manufacturing and fibre recycling, secondary data from Ecoinvent database (version not specfified). Experimental data for recycling. Ecoinvent data for other waste scenarios (landfill and incineration with energy recovery).	3
	1. Raw materials	Primary data from suppliers of manufacturer (virgin fibres and MDF wastes from MDF and furniture industry).	*3*
	2. Manufacturing	Primary data from a German plant, data converted to a large scale plant in UK (electricity..) UK manufacturing data taking from Wood Panel Industries Federation (WPIF) and FIRA.	*3*
	3. Distribution/transportation	LCI data from Ecoinvent. Company information on the specific vehicles used. Euro IV emissions applied.	*3*
	4. Use phase	-	-
	5. Packaging	-	-
	6. End of Life	Information on the recycling process camefrom experimental data (from C-Tech, published in the literature in 2007). Ecoinvent provided inventory data for the rest of waste scenario options (landfill and incineration). Incineration with energy recovery was considered (heating value of waste: 15 MJ/kg). For landfill, data on decomposition of generic untreated wood in landfill was used (not available for MDF waste).	*3*
	TOTAL		S_{DATA} = *3*

10	**Impact assessment categories/methods**	CML 2000 baseline (Characterisation) 1.Global warming potential (GWP) (classification A) 2.Ozone layer depletion (ODP) (classification A) 3.Acidification potential (classification B) 4.Photochemical oxidation (classification B) 5.Eutrophication potential (classification B) 6.Abiotic depletion potential (not considered as key indicator) 7.Human toxicity (not considered as key indicator) 8.Ecotoxicity (not considered as key indicator) Satisfactory broadness (with respect to the impact categories identified earlier) AND all indicators of interest are evaluated as A or B (best in class) according to ILCD.	$S_{IMPACTS}$ = 5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	The study assesses the environmental impacts due to the substitution of virgin fibres by recycled fibres. Increasing the content of recycled fibres leads to a reduction in many environmental impact categories such as global warming potential, eutrophication and ecotoxicity. Compared to virgin MDF production, the 10% rMDF board shows a reduction in some impacts categories such as global warming potential, eutrophication and ecotoxicity. Improvement potential can be still higher if the recycled content is increased to 20%. Related to the functional unit, there is a potential reduction of 0.52 tonnes of CO_2 eq. per tonne of rMDF 20%produced. In the manufacture of the virgin MDF boards, the fibre production stage (wood extraction and conversion into fibres) has the highest environmental impacts due to energy use, chemical additive production and transportation processes. Minimizing the use of virgin fibres would reduce environmental impacts inherently due to materials. However, much of the internal MDF waste can be alternatively used also to support the production of heat for the manufacturing process, which allows avoiding gas combustion partially or totally. It is thus apparent there is a sort of competition for the use of the secondary resource, and a balance between these two possible alternatives must be evaluated carefully. For low recycled fibres contents there is an increase of impacts (abiotic depletion, ozone layer depletion and acidification) where gas emissios has higher contribution that waste incineration emissions. The missed energy recovery form waste MDF indeed must be compensated through the combustion of gas, according to the assumptions of the study. However, there is an overall reduction of impacts when the recycled faction is increased to 20% due to the avoidance of the energy used in virgin fibre production. A decrease in resin content also produces a decrease of about 1% in all impact categories, although magnitude of variation of the environmental impacts is not so significant. Regarding transport of MDF recycled fibres to MDF board production plant (0 km if they come from the own plant to 100 km if waste come from furniture industries), increasing the distance travelled by the fibres marginally increases the environmental impacts over all the categories studied. However, this is not a significant increase. Regarding the transport of sourcing materials (form 75 to 245 km), local materials were shown to have lower environmental impacts, but differences are not significant. Regarding waste treatment, the highest and lowest environmental impacts are associated to disposal in landfill and on-site production of energy, respectively. On-site energy allows avoiding the use of combustion gas. Recycling has also the potential to decrease impacts by avoiding the production virgin fibres. However, when avoided processes are considered, recycling has lower impacts for the majority of impact categories in comparison with the rest of treatment options.	$S_{OUTCOMES}$ = 3
12	**Strengths and weakness of the whole study, general comments**	The overall quality of the study is considered good (in terms of modeling, assumptions, data gaining, impacts assessment, presentation and discussion of results, findings) and its strength is that the study dealing with a very specific material (MDF) and it is not focused on its application in furniture.	$S_{ROBUSTNESS}$ = 3
13	**Subject to independent review?**	Critical reviewed by external panel	S_{REVIEW} = 5

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}= 3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} =18**
5	***Item***	***Observation***	***Scoring***
1	**title**	Scrivania - Martex, LCA – VALUTAZIONE DEL CICLO DI VITA[100]	-
2	**authors**	IGEAM - Unione Industriali Pordenone.	-
3	**reference and year**	Private documentation from industry. 2010	-
4	**type of study**	Attributional LCA according to ISO 14040. Goal: to define criteria for furniture Ecolabel	S_{SCOPE} = 3
5	**scope**	Desk, Italy Composition: Chipboard 42%, aluminium 35%, ABS 1%, Zama 5%, Steel 4%, Nylon 0,3%, Packaging 13% (cardboard 12%, polystyrene 1%, polypropylene 1%)	
6	**functional unit**	Functional unit: 10 kg of desk The studied desk is 180cm x 80 cm, made of chipboard with legs and perimeter of aluminium	
7	**system boundaries**	Cradle-to-gate Processes included: • Upstream module: includes the activities of production of materials, semi-finished products and packaging, by Suppliers as well as transportation of the components at the Facility Martex; • Core module: includes work performed at the Facility Martex. The transportation to customers, as well as the impacts related to maintenance (cleaning,	

		or replacement parts) of the cabinet and waste treatment have not been considered.	
8	**assumptions (e.g. allocation)**	The breakdown of electricity was performed in the following way: • For linear meter board edge for the activities of drilling-edge; • per m3 of panel worked for general consumption facility. Panels received about 70% of painting. Since the particle board which constitutes the top of the desk object of the study does not undergo further surface treatment, it is speculated that, as regards the thermal energy, the consumption of OCD and wood shavings can be attributed to the 30% of the heating and this is allocable share of the total volume of the used panels.	
9	**data sources and quality**	Primary data from Martex and components suppliers (questionnaires from Martex company year 2008), Boustead model for secondary data (version 5.0)	
	1. Raw materials	Primary data from Martex suppliers.Data from existing EPDs for chipboard. Transport of components from suppliers to plant considered according to average number and distance of annual deliveries (2008). Boustead model and databases for secondary data.	*3*
	2. Manufacturing	Primary data from manufacturer and components suppliers (year 2008). LCI data from Boustead model database (version 5.0)	*3*
	3. Distribution/ transportation	-	
	4. Use phase	-	
	5. Packaging	Primary data from packaging suppliers, Boustead model (version 5.0)for secondary data.	*3*
	6. End of Life	-	
	TOTAL		S_{DATA} *=3*
10	**Impact assessment categories/methods**	Characterisation. –Climate change - IPCC (classification A) –ODP - Solomon, 1992, Nordic Guidelines; (not classified) – Acidification potential – CML 1999 (classification B) –Photochemical oxidation potential – CML 1999 (classification B) –Eutrophication Potential - CML 1999 (classification B)	$S_{IMPACTS}$ = 5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Main consumptions and impacts are due to components production (97.9% of energy consumption, 96% of global warming, 95.4% of acidification, 97% of eutrophication, 95.9% of photochemical ozone formation) since the manufacturing process consists basically in assembling different components and desk surface is no painted. In spite of its weight share (39.9%), impacts are mostly due to aluminium which has a relative weight of 35% of total weight (with highest values for 79% of energy consumption, 84% of global warming, 81% of acidification). Chipboards forms 48% of the weight but contributes less to the environmental impacts (13.1% of energy consumption, 2.1% of global warming). Another material with relevant impacts is the Zamak alloy (8% on average). 6% of the impacts is caused by packaging materials. The manufacturing process has a marginal contribution to the impacts that is almost equally split between three processes: cutting, painting and coating and facility consumptions A high amount of electricity (70%) is consumed during the painting and coating of edges, mainly for drying on furnaces. Sensitive analysis was carried-out to evaluate the energy consumption of primary and secondary aluminium. The use of recycled aluminium can reduce the energy consumption by 89% (145 MJ/kg for virgin aluminium and 15.9 MJ/kg for recycled aluminium).	$S_{OUTCOMES}$ =3
12	**Strengths and weakness of the whole study, general comments**	The main weakness of the study is that the scope is from cradle-to gate. Nevertheless, assessment of materials, components and manufacturing of the final product represent useful information.	$S_{ROBUSTNESS}$ = 3
13	**Subject to independent review?**	Not reviewed	S_{REVIEW} = 1

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}=3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} =18**
6	***Item***	***Observation***	***Scoring***
1	**title**	Postazione di Lavoro Alea, LCA – VALUTAZIONE DEL CICLO DI VITA[101]	
2	**authors**	IGEAM - Unione Industriali Pordenone.	-
3	**reference and year**	Private documentation from industry, 2010	-
4	**type of study**	Attributional LCA according to ISO 14040	S_{SCOPE} = 3
5	**scope**	Workplace: (Italy) Composition by weight: chipboard melamine paper 52.41%, aluminium 24.84%, ABS 1.23%, Zama 6.69 %, Nylon 0.04%, Steel / Iron 14.77%, Beech 0.02%, Brass 0.01%	
6	**functional unit**	10 kg of workplace The workplace studied is: • 170 cm x 70 cm desk made of plan chipboard with melamine paper and aluminium • 100 cm x 50 cm auxiliary table independent made of plan chipboard with melamine paper and aluminium; • Drawer made of chipboard and classifier.	
7	**system boundaries**	Cradle-to-gate Processes included: • Upstream module: includes the activities of production of materials, semi-finished products and packaging, by Suppliers as well as transportation of the components at the Facility of manufacturer; • Core module: includes work performed at the Facility of manufacturer.	

		The transportation to customers, as well as the impacts related to maintenance (cleaning, or replacement parts) of the workplace and waste treatment have not been considered.	
8	**assumptions (e.g. allocation)**	Input of energy in the manufacturing plant have been split between different stages: • The electricity has been broken down based on the volume (m^3) of panel worked (for cutting, edging and drilling routing operations). • The thermal energy was split based on the volume (m^3) of particle board worked: 80% for heating work environments, 20% for painting. The consumption of thermal fusing glue for edging was spread over the linear feet of the applied edge. The distribution of glue for packaging (vinyl and thermal fusing glues) was performed on the basis of the number of packages and products All waste products, with the exception of those related to the painting process because excluded from the calculation, were split based on the volume (m^3) of panel worked. The emissions into the atmosphere, except those related to the painting cycle, were considered and were split by the volume (m^3) of panel worked.	
9	**data sources and quality**	Primary data from the production plant of Alea di Caneva (Italy) and from components suppliers (year 2008), Boustead model (version 5.0) for secondary data	
	1. Raw materials	Primary data from suppliers. Data from existing EPDs for chipboards. Transport of components from suppliers to plant considered according to average number and distance of annual deliveries (2008). Boustead model and other database for secondary data (version 5.0)	*3*
	2. Manufacturing	Primary data from manufacturer and components suppliers (year 2008). LCI data from Boustead model (version 5.0)	*3*
	3. Distribution/transportation	-	
	4. Use phase	-	
	5. Packaging	Primary data from packaging suppliers and plant operations on packaging. Boustead model for secondary data.	*3*
	6. End of Life	-	
	TOTAL		S_{DATA} =*3*
10	**Impact assessment categories/methods**	Characterisation. –Climate change - IPCC (classification A) –ODP - Solomon, 1992, Nordic Guidelines; (not classified) – Acidification potential – CML 1999; (classification B) –Phochemical oxidation potential – CML 1999 (classification B) –Eutrophication Potential - CML 1999 (classification B)	$S_{IMPACTS}$ =5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Main consumptions and impacts are due to upstream processes, i.e. components production and transport to plant (89.7% of energy consumption, 85% of global warming, 85% of ozone depletion, 77.5% of acidification, 82% of eutrophication, 77.5% of Photochemical ozone formation). 6% is caused by packaging materials. In spite of its weight share (25%), impacts are mostly due to aluminium (60% of energy consumption, 84% of global warming, 81% of acidification). ABS edges of drawer have a high contribution in the ozone depletion category, whereas for desk and auxiliary table the major contributor is the panel board. The manufacturing process has a marginal contribution to the impacts that are mainly due to energy consumption. Sensitive analysis was carried-out to evaluate the energy consumption of primary and secondary aluminium. The use of recycled aluminium can reduce the energy consumption by 89% (145 MJ/kg for virgin aluminium and 15.9 MJ/kg for recycled aluminium).	$S_{OUTCOMES}$ =3
12	**Strengths and weakness of the whole study, general comments**	The main weakness of the study is that the scope is from cradle-to gate. Nevertheless, assessment of materials, components and manufacturing of the final product represent useful information.	$S_{ROBUSTNESS}$ = 3
13	**Subject to independent review?**	No review	S_{REVIEW} = 1

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}= 3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} =18**
7	***Item***	***Observation***	***Scoring***
1	**title**	Armadio Mascagni – Dall'Agnese, LCA – VALUTAZIONE DEL CICLO DI VITA,[102]	-
2	**authors**	IGEAM - Unione Industriali Pordenone.	-
3	**reference and year**	Private documentation from industry, 2010	-
4	**type of study**	Attributional LCA according to ISO 14040	S_{SCOPE} =3
5	**scope**	Wardrobe (Italy). Composition: Chipboard and MDF 16%, Ramin 0.13%, plastic 0.04%, glass 6%, wooden panel 43%,,tulipwood 22%, hardware wood 1%, fir 2%, veneer 5%, other (glass and finishes components 3%,packaging 5%	
6	**functional unit**	10 kg of cabinet (without considering packaging). Characteristics of the studied cabinet: •236.7 cm high; •doors of 52.5 cm each (only one is of 4.70 cm); •cherry veneer wood finish.	
7	**system boundaries**	Cradle-to-gate Processes included: • Upstream module: includes the activities of production of materials, semi-finished products and packaging, by Suppliers as well as transportation of the components at the	

		Facility of manufacturer; • Core module: includes work performed at the Facility of manufacturer. The transportation to customers, as well as the impacts related to maintenance (cleaning, or replacement parts) and waste treatment of the cabinet have not been considered.	
8	**assumptions (e.g. allocation)**	Allocation of electricity consumption in the manufacturing process • based on volume (m^3) of panel worked for the activities of cutting, finishings, and facility; • based on surface (m^2) for the task of finishing with veneer, painting and finishing; • based on the number of packages for the assembly. With respect to the thermal energy, consumption of methane is equally split production and heating environments.	
9	**data sources and quality**	Primary data from the production plant of Alea di Caneva and from components suppliers (year 2008). Boustead model for secondary and LCI data (version 5.0)	
	1. Raw materials	Primary data from suppliers. Data from existing EPDs for panel boards. Transport of components from suppliers to plant considered according to average number and distance of annual deliveries (2008). Boustead model and databases for secondary data.	*3*
	2. Manufacturing	Primary data from manufacturer and components suppliers (year 2008). Boustead model for secondary and LCI data (version 5.0)	*3*
	3. Distribution/transportation	-	
	4. Use phase	-	
	5. Packaging	Primary data from packaging suppliers and plant operations on packaging. Boustead model for secondary data (version 5.0)	*3*
	6. End of Life	The theoretical degree of recyclability of the cabinet at the end of life is estimated at approximately 84%, taking into account the following assumptions: Plastic: 100% heat recovery; Glass Mirrors:100%; Chipboard 90%; Panel woods 85%; Solid 100%; Hardware 100%, Finishes 0%	*3*
	TOTAL		S_{DATA} =*3*
10	**Impact assessment categories/methods**	Characterisation. –Climate change - IPCC (classification A) –ODP - Solomon, 1992, Nordic Guidelines; (not classified) – Acidification potential – CML 1999; (classification B) –Phochemical oxidation potential – CML 1999 (classification B) –Eutrophication Potential - CML 1999 (classification B)	$S_{IMPACTS}$ = 5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Main consumptions and impacts are due to upstream processes, i.e. components production and transport to plant (73.3% of energy consumption, 61% of global warming, 84% of ozone depletion, 72.7% of acidification, 77% of eutrophication). Among materials, wooden panels have the biggest contribution, since it is the main component with a 41.39% of weight (they contribute to 41.39% of energy consumption, 40% of Global warming, 35.2% of acidification potential, . 6% of the impacts on average is caused by packaging materials. The product manufacture process has the highest contribution only for photochemical ozone formation (87.8%), mainly due to atmospheric emissions resulting from coating systems (emission of solvent in paints and varnishes, fillers and diluents. In particular, solvents based on xylene, contribute with about 35%. A significant proportion of the impacts can be due also to the emissions of other unspecified solvents. Naphthenes can contribute to POCP by more than 23% due to the presence of cycle primarily alkanes in the products of UV coating. The presence of toluene as a diluent in paint products, both UV and polyurethane-based, can also contribute significantly to the POCP. Other impacts associated to the manufacturing processes are mainly due to the energy consumption for coating (UV coating, PUR and paints).	$S_{OUTCOMES}$ =3
12	**Strengths and weakness of the whole study, general comments**	The main weakness of the study is that the scope is from cradle-to gate. Nevertheless, assessment of materials, components and manufacturing of the final product represent useful information.	$S_{ROBUSTNESS}$ =3
13	**Subject to independent review?**	No review	S_{REVIEW} =1

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}= 3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} =18**
8	***Item***	***Observation***	***Scoring***
1	**title**	Armadio – Martex, LCA – VALUTAZIONE DEL CICLO DI VITA,[103]	-
2	**authors**	IGEAM - Unione Industriali Pordenone.	-
3	**reference and year**	Private documentation from industry, 2010	-
4	**type of study**	Attributional LCA according to ISO 14040	S_{SCOPE} = 3
5	**scope**	Wardrobe (Italy). Composition by weight: particle board 49%, wooden panels 9%, Wood veneer 0.2%, EPDM rubber 0.4%, Aluminium 11%, Steel 0,2%, Paper 0.1%, ABS 0.1%, Zama 0.01%, Nylon 0.1%, Glass 17%, Iron/Steel 0.8%, Packaging 12%	
6	**functional unit**	the weight of 10 kg of Cabinet, (without considering packaging). Characteristics of cabinet: •259.6 cm high •2 sliding doors of 135 cm , white lacquer finish with mirrored doors.	
7	**system boundaries**	Cradle-to-gate Processes included: • Upstream module: includes the activities of production of materials, semi-finished	

		products and packaging, by Suppliers as well as transportation of the components at the Facility of manufacturer; • Core module: includes work performed at the Facility of manufacturer. The transportation to customers, as well as the impacts related to maintenance (cleaning, or replacement parts) and treatment waste of the cabinet have not been considered.	
8	**assumptions (e.g. allocation)**	Electricity consumption in the manufacture stage was allocated: • Based on the length (m) of board edging for the drilling-sledge; • Based on the volume (m3) of panel worked for the general consumption in the facility; • Based on the surface (m2) of the panel for the application of the insulation roll and lacquering. The consumption of thermal energy has been completely attributed to the activities of painting and therefore broken down according to the surface (m2) of panel treated.	
9	**data sources and quality**	Primary data from producer and components suppliers (year 2008). Boustead model for secondary and LCI data (version 5.0)	
	1. Raw materials	Primary data from suppliers. Data from existing EPDs for chipboards. Transport of components from suppliers to plant considered according to average number and distance of annual deliveries (2008). Boustead model and databases for secondary data. Upstream module includes: • extraction and production of raw materials and basic materials • Production of fuels, heat, electricity and related emissions • Production of auxiliary materials for the assembly and manufacture of furniture • Transportation of the components from the supplier to the manufacturer • Production of waste from the Upstream	*3*
	2. Manufacturing	Primary data from manufacturer and components suppliers (year 2008) Core Module includes: • Electricity, heat and auxiliary materials used for the assembly of parts and work performed on the cabinet; • emissions generated by the process Core; • Waste Generation Core Process Data on fuel consumption and emissions of the plant Martex refer to the year 2008.	*3*
	3. Distribution/transportation	The study does not include transportation to the customer.	
	4. Use phase	-	
	5. Packaging	Primary data from packaging suppliers, Boustead model for secondary and LCI data (version 5.0)	*3*
	6. End of Life	-	*3*
	TOTAL		S_{DATA} =*3*
10	**Impact assessment categories/methods**	Characterisation. –Climate change - IPCC (classification A) –ODP - Solomon, 1992, Nordic Guidelines; (not classified) – Acidification potential – CML 1999; (classification B) –Phochemical oxidation potential – CML 1999 (classification B) –Eutrophication Potential - CML 1999 (classification B)	$S_{IMPACTS}$ = 5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Main consumptions and impacts are due to upstream processes, i.e. components production and transport to plant: - 80.5% for energy consumption - 72% for climate change, related to energy consumption - 98% for ozone depletion (due to acrylic adhesives of chipboards and polystyrene used in packaging) - 79% for acidification (due to emissions of oxides of sulfur and nitrogen from combustion of heavy fuels for heat and electricity needed to process materials.) - 88.9% for eutrophication. The major contributions are related to the electrical and thermal consumption related to processing and production of semi-finished products, in particular of aluminum, glass, and particle and wooden boards. - 80.9% for photochemical ozone formation. The greatest contribution is given by the production of acrylic adhesives used in pressing services. The other input is tied to the production of chipboard and, in small part, to the production of polystyrene used in packaging. In spite of its weight share (13%), impacts are mostly due to aluminium (47% of energy consumption, 65% of global warming). A considerable share is also associated to the production of particle board with a relative weight of 49% (32.65% of energy, 6.8% of global change, 7.9% of acidification, , Glass has also relevant contribution especially in energy consumption and global change. The manufacturing process contributes to lifecycle impacts between 2-28%. This is mainly due to the demand of heat in the coating process (70% of the energy consumption of manufacture, 78% of climate change), which includes painting and application of the insulation roll.	$S_{OUTCOMES}$ = 3
12	**Strengths and weakness of the whole study, general comments**	The main weakness of the study is that the scope is from cradle-to gate. Nevertheless, assessment of materials, components and manufacturing of the final product represent useful information.	$S_{ROBUSTNESS}$ =3
13	**Subject to independent review?**	no review	S_{REVIEW} =1

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}=3 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		S_{TOTAL} =18
9	Item	Observation	Scoring
1	**title**	Cucina Samoa – Copat, LCA – VALUTAZIONE DEL CICLO DI VITA[104]	-
2	**authors**	IGEAM - Unione Industriali Pordenone.	-
3	**reference and year**	Private documentation from industry, 2010	-
4	**type of study**	Attributional LCA according to ISO 14040	S_{SCOPE} = 3
5	**scope**	Kitchen (Italy). Materials composition by weight: Chipboard panel 89%, Steel 7%, Aluminium 1.4%, ABS 0.7%, PVC 0.3%, Zama (Zinc alloy) 0.7%, MDF fibre 1.4%, MDF band 0.4%, Others 0.1%	
6	**functional unit**	Weight of 10 kg of kitchen modello Samoa(net weight excluding electrical appliances and packaging of storage and delivery). Main material: chipboard (89% of weight).	
7	**system boundaries**	Cradle-to-gate Processes included: • Upstream module: includes the activities of production of materials, semi-finished products and packaging, by Suppliers as well as transportation of the components at the Facility of manufacturer; • Core module: includes work performed at the Facility of manufacturer. The transportation to customers, as well as the impacts related to maintenance (cleaning, or replacement parts) of the cabinet have not been considered. The paper in melamine faced chipboard panels, as well as hardware items are purchased from Copat by its network providers. The same applies to the packaging, adhesives and coating materials used in the processing cycle. Once in the warehouse, the panels are distributed on two distinct lines: • one which concerns the working on the panels of the structural part; • one that concerns the processes on the panels of the top kitchens. The first line includes the steps of cutting, edge-banding, drilling. The second involves a block sizing and team-specific edging, returning them to the top of the panels flow with that of other structural panels upstream of the hole. Once processed the various panels are sent to the next assembly plant, where the various pieces are grouped, partly assembled, and packed with the part of hardware required.	
8	**assumptions (e.g. allocation)**	Allocation of input and output in manufacturing The flow data input and output of the plant Copat have been allocated, providing the company with a precise accounting system for cost center, on the different phases in which the production process has been broken down. As regards the consumption of electricity, electricity flows were then broken down as follows: • per m3 of panel worked for the activities of sizing (both top panels), drilling and assembly, and facility; • for m linear border applied to the activity of edge-banding (both panels Top). As regards the thermal energy, the consumption of chips and oil BTZ related only to part of production, while diesel fuel is used for heating in the workplace of the assembly site.	
9	**data sources and quality**	Primary data from manufacturer and components suppliers (year 2008). Boustead model for secondary data (version 5.0)	
	1. Raw materials	Primary data from suppliers. Data from existing EPDs for chipboard. Transport of components from suppliers to plant considered according to average number and distance of annual deliveries (2008). Boustead model and databases for secondary data (version 5.0) Upstream module includes: • Extraction and production of raw materials and basic materials • Production of fuels, heat, electricity and related emissions • Production of auxiliary materials for the assembly and manufacture of furniture • Transportation of the components from the supplier to the manufacturer • Production of waste from the Upstream	3
	2. Manufacturing	Primary data from manufacturer and components suppliers (year 2008). Main components are chipboard panels, for both structural part and tops. These are produced in two distinct lines. The first line includes the steps of cutting, edge-banding, drilling. The second involves a block sizing and team-specific edging. Once processed, the various panels are sent to the next assembly plant, where the various pieces are grouped, partly assembled, and packed. Core Module: • Electricity, heat and auxiliary materials used for the assembly of parts and work performed on the model kitchen Samoa; • Emissions from process Core; • Waste Generation Core Process Data on fuel consumption and emissions of the factories Copat refer to the year 2008.	3
	3. Distribution/transportation	The study does not include transportation to the customer.	
	4. Use phase	-	
	5. Packaging	Primary data from packaging suppliers, Boustead model for secondary data (model 5.0)	3
	6. End of Life	-	3
	TOTAL		S_{DATA} =3
10	**Impact assessment**	Characterisation.	$S_{IMPACTS}$

	categories/methods	–Climate change - IPCC (classification A) –ODP - Solomon, 1992, Nordic Guidelines; (not classified) – Acidification potential – CML 1999; (classification B) –Phochemical oxidation potential – CML 1999 (classification B) –Eutrophication Potential - CML 1999 (classification B)	= 5
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Main consumptions and impacts are due to upstream processes, i.e. components production and transport to (67.1% of energy consumption, 60% of global warming, 90% of ozone depletion, 45% of acidification, 70% of eutrophication, 35.55% of Photochemical ozone formation). Among materials, main impacts are due to chipboard production (77% of energy consumption, 28% of global warming, 47.7% of acidification, 82% of eutrophication). It should be highlighted that steel and aluminium, which together account for 8.5% of the total weight of the kitchen, require for their production about 15% of the energy and causes a big share of impacts (59% of global warming, 23.2% of acidification, 11% of eutrophication). PVC and PVA are the major contributors for the Ozone Depletion Potentia, since only 1.5 kg of PCV contribute to 75% of ODP respecting other materials.l. For the manufacturing processes, the main contributions in all impact categories are due to energy consumption (electricity and fuels for heating). Lacquering process has also relevant impacts for the presence of diluents aromatic (styrene), particularly for Photochemical Ozone Creation Potential category, where manufacturing has a contribution of 64.5%.	$S_{OUTCOMES}$ = 3
12	**Strengths and weakness of the whole study, general comments**	The main weakness of the study is that the scope is from cradle-to gate. Nevertheless, assessment of materials, components and manufacturing of the final product represent useful information.	$S_{ROBUSTNESS}$ = 3
13	**Subject to independent review?**	no review	S_{REVIEW} = 1

TOTAL SCORE	S_{SCOPE}= 5 S_{DATA}=2.6 $S_{IMPACTS}$= 1 $S_{OUTCOMES}$ = 5 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} = 17.6**
10	***Item***	***Observation***	***Scoring***
1	**title**	Life-Cycle Assessment of Office Furniture Products. Final report on the study of three Steelcase office furniture[105]	-
2	**authors**	Center for Sustainable Systems. University of Michigan	-
3	**reference and year**	http://css.snre.umich.edu/css_doc/CSS06-11.pdf; 2006	-
4	**type of study**	LCA study according to ISO 14044	S_{SCOPE} = 5
5	**scope**	Table, desk, and chair (USA). –Table: Steel 45%, Particleboard 30%, Aluminium 25%, Laminate 0.03%, Adhesive and Plastics.0.01%. –Desk: Particleboard 59% by weight, Steel 20%, Plywood 15%, Cherry 3%, Other Wood/Paper 1.2%, Adhesives and Finishes 0.7%, Backing Material 0.6%, Plastics 0.6%; Chair: Steel 50% by weight, Plastic 23%, Non-ferrous metals 21%, Leather 4%, Other 3%.	
6	**functional unit**	- Table: 30 years of flat work space adjustable from 26” to 43” in height while supporting up to 25 lbs. - Desk: 30 years of stand alone 72”x36” work surface use, including storage, in a wood office environment. - Chair: 30 years of ergonomic executive seating in a wood office environment.	
7	**system boundaries**	Cradle-to-grave full product life-cycle including acquisition of all materials from the ground, processing and fabrication of component parts, production and assembly of final product, distribution of materials, parts and final product, product use, and end of life management. This analysis considers the life-cycle environmental burdens for material acquisition, processing and forming related to parts and materials consistent with accounting for at least 99% of final product composition . Product and sub-assembly manufacturing are modeled. Delivery of materials, parts and final products are included inthe system boundary. Although 30 years is taken as the nominal lifetime for all systems studied, noimpacts are known to occur during use. End of life collection of discarded furniture and processing ofmaterials is included in the analysis. Stages excluded: transport of workers, customers, R&D and marketing activities, impacts of pint of selling and platforms of distribution, transport of waste.	
8	**assumptions (e.g. allocation)**	Mass allocation for manufacturing different products of Steelcase facilities.	
9	**data sources and quality**	Primary data from Steelcase representatives (United States). Secondary data from previous studies.	
	1. Raw materials	Materials used in Steelcase products. Processing data from previous LCA studies: Plastics data from reports of the Association of Plastic Manufacturers in Europe (APME) (Bousted 2005). Steel data from the International Iron and Steel Institute (IISI) (IISI 2002). Aluminium data from studies conducted by the Aluminum Association. Wood data from Consortium for Research on Renewable Industrial Materials (CORRIM) (Wilson and Sakimoto 2004). Particleboard process modeled by Steelcase	*3*
	2. Manufacturing	Steelcase facilities and contract manufacturers. Data based on equipment use and duration of each process. This included information on the key assembly and production processes which focused on the equipment use and duration for each process step. Data on electricity, compressed air, and water use were available from the previous study for 17 types of manufacturing equipment used at Steelcase. Information on operating requirements for any equipment were collected by Steelcase. Additionally, information on the yield associated with product processing was estimated by Steelcase.	*3*

		Equipment operating requirements were input into SimaPro and combined with data on US average electricity production, compressor operation, and potable water production to calculate inventory results for the manufacturing stage.	
	3. Distribution/transportation	Movement of parts and sub-assemblies to the production location (Steelcase). Final product deliveries modelled according to information provided by Steelcase on the expected volume for major customer locations.	*3*
	4. Use phase	30 years taken as nominal lifetime (no impacts)	-
	5. Packaging	packaging types, weight, and material for each product	*3*
	6. End of Life	US EPA data. (Municipal Solid Waste in the United States; October 2003, Washington D.C.) Specific recovery rates for different materials are derived from data on durable goods (incl. appliances) as well as packaging and containers. Remaining waste after material recovery is either combusted or landfilled at rates of 14.7% and 55.7% respectively. 29.6% of the remaining waste is directed towards unknown waste treatment.	*1*
	TOTAL		S_{DATA} =*2.6*
10	**Impact assessment categories/methods**	TRACI methodology (US, EPA): - Global warming potential (kg CO2 eqv.)(Classification A) - Acidification potential (H+ mol eqv.) (Classification E) - Energy resource consumption (MJ) (not considered as key indicator) - Criteria pollutants/human health (kg PM2.5 Eqv) (not considered as key indicator) - Solid waste (kg); Total material consumption (kg) (not considered as key indicator)	$S_{IMPACTS}$ =1
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Although direct comparison among the 3 systems is not possible, relative impacts relating to the relative importance of product mass versus material composition can be observed. It was found that the least energy intensive product in relation with the product mass is that composed of wood for a greater amount (less energy intensive). The role of specific system parameters in the overall results were further investigated in a sensitivity analysis. Particleboard resin content and extruded aluminium recycling rate were found to be the most significant parameters in determining overall system performance. Particleboard composition was varied to analyse the effects due to a reduction of the mass contribution of urea-formaldehyde resins from the current level of 9.5% to 4.9% by weight. Reductions for all key categories would be achieved: 20% for global warming, 58% for acidification potential. The content of secondary aluminium was doubled from 11% to 22% by weight to understand the influence of recycled content on the life-cycle performance. Reductions for all key categories would be achieved: 54% of global warming, 62% of acidification potential.	$S_{OUTCOMES}$ = 5
12	**Strengths and weakness of the whole study, general comments**	Study done for USA company and TRAC1 impact method. Detailed information at inventory level and useful sensitive analysis.	$S_{ROBUSTNESS}$ =3
13	**Subject to independent review?**	No review	S_{REVIEW} =1

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}= 1 $S_{IMPACTS}$= 5 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 3 S_{REVIEW}=1		**S_{TOTAL} =16**
11	***Item***	***Observation***	***Scoring***
1	**title**	Life Cycle Assessment. A product-oriented method for sustainability analysis Training Manual.[121]	-
2	**authors**	UNEP SETAC.	-
3	**reference and year**	http://global-mechanism.org/specials/msc_toolkit/material/Background_documents/Further%20reading/Life%20Cycle%20Assessment%20TrainingManual.pdf, 2008	-
4	**type of study**	LCA study according to ISO14040/4044. Consequential approach at end-of-life phase (avoided impacts from desk incineration to obtain energy)	S_{SCOPE} = 3
5	**scope**	School desk made of 100% FSC certified pinewood (Mexico)	
6	**functional unit**	use of the one desk for eight years, which is the estimated lifetime of the desk	
7	**system boundaries**	Cradle-to-grave The study includes all of the material and energy inputs required in the production of the school desk, with a few noted exceptions. It includes electricity production in Mexico and the operations from the sawmill to the production of the desk, as well as transportation within these operations. Life cycle stages studied include FSC certified wood growth and harvesting, transportation, cutting of the logs into boards, manufacturing of the boards into school desks, distribution of the desks to the schools, and use of the used desks as fuel in an industrial boiler. The study excludes any chemicals or water that may be used during use stage	
8	**assumptions (e.g. allocation)**	Economic allocation of inputs and outputs for board sawing (80% to sawn wood products and 20% to sawdust) and desk fabrication (95% to desk, 5% to sawdust).	
9	**data sources and quality**	Primary data referring to Mexico and provided by CADIS, Center for LCA and Sustainable Design (Mexico). Secondary data: IDEMAT, Ecoinvent, Franklin, Franklin Associates (range of years considered is 1990 to 2008)	
	1. Raw materials	There were no chemical inputs for fertilizer or pesticides in the growth of the logs, due to lack of data about potential fertilizer, pesticide or herbicide use that may be used in non-FSC certified forests.	*1*
	2. Manufacturing	The furniture factory is adjacent to the mill so transportation impacts were negligible. The boards were cut, assembled with galvanized screws and finished with a lacquer coating. The manufacturing plant uses multipurpose wood working machines that were built in the 1990s. The steel containers for the lacquer were collected for recycling, however the	*1*

12		transport of the containers was excluded from the assessment. Transportation of the screws to the factory was also excluded from the study, as were packaging materials for the screws.	
	3. Distribution/ transportation	The desks are trucked 80 kilometers to a retail store, and shipped an average distance of 40 kilometers to the schools.	*1*
	4. Use phase	The desks are used an average of eight years before they are discarded. The study excludes any cleaning chemicals or water that may be used during the life cycle of the desks	-
	5. Packaging		*1*
	6. End of Life	At the end of life, the desks are trucked 80 km to be burned as fuel in industrial boilers. The energy created by the combustion of the wood is an “avoided input” of natural gas that would have been combusted to heat water. This is calculated as a negative impact. Additionally, the CO_2 created by the combustion of the wood is “cancelled” because the wood is biogenic and renewable.	*1*
	TOTAL		S_{DATA}=1
10	**Impact assessment categories/methods**	CML 2 baseline 2000 characterisation method: –global warming kg CO_2 eq (Classification A) –ozone layer depletion kg CFC-11 eq (Classification A) –acidification kg SO_2 eq (Classification B) –photochemical oxidation kg C_2H_4 eq (Classification B) –eutrophication kg PO_4- eq (Classification B) –abiotic depletion kg Sb eq (not considered as key indicator) –human toxicity kg 1,4-DB eq (not considered as key indicator) –fresh water ecotoxicity kg 1,4-DB eq (not considered as key indicator) –terrestrial ecotoxicity kg 1,4-DB eq (not considered as key indicator)	$S_{IMPACTS}$ = 5
12	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	The board sawing and drying stage makes the largest contribution to environmental impacts. The impacts are caused by emissions from fossil fuel combustion for electricity production. Significant impacts were also created by combustion of fuel for desk fabrication processes.	$S_{OUTCOMES}$ =3

CML 2001 Impact cat.	Units	Extraction	Sawing & drying	Desk fabrication	Distribution	Use	Energy recovery	Total per desk life
abiotic depletion	kg Sb eq	5.07E-02	5.73E-01	2.46E-01	1.20E-03	0	-5.29E-02	8.18E-01
global warming	kg CO2 eq	9.35E+00	9.39E+01	4.14E+01	1.81E-01	0	-1.10E-01	1.45E+02
ozone layer depletion	kg CFC-11 eq	0.00E+00	9.50E-05	-9.50E-05	0.00E+00	0	-2.34E-03	-2.34E-03
human toxicity	kg 1,4-DB eq	3.91E-02	2.10E+01	5.42E+00	3.07E-02	0	2.64E-01	2.68E+01
fresh water ecotoxicity	kg 1,4-DB eq	0.00E+00	4.50E+00	9.03E-01	1.40E-03	0	-5.55E-03	5.40E+00
terrestrial ecotoxicity	kg 1,4-DB eq	0.00E+00	9.20E+00	1.03E+00	9.98E-05	0	1.31E-03	1.02E+01
photochemical oxidation	kg C2H4 eq	4.15E-03	-4.58E-02	8.65E-02	-7.72E-08	0	-2.64E-03	4.22E-02
acidification	kg SO2 eq	1.15E-01	1.55E-01	3.47E-01	9.98E-04	0	-1.04E-01	5.14E-01
eutrophication	kg PO4- eq	3.33E-03	4.28E-02	4.85E-02	2.00E-04	0	-9.70E-04	9.39E-02

		The energy recovery stage though incineration at end of life avoids a modest portion of the impacts created in the entire lifecycle. A significant amount of ozone layer depletion is avoided by burning the wood at the end of life instead of burning natural gas to heat water. To compare the relative scale of each of the impacts associated to the production of the school desk, each impact category was divided bvy the normalization factors provided within the CML Baseline 2000 methods and referred to the global estimations for 1995. The normalised values indicate that the impact categories contributing mostly on a global scale are terrestrial ecotoxicity, abiotic resource depletion and global warming.. A variety of data in the process inventory of this wooden desk can be used to perform sensitivity analysis. One example is the assumed lifetime of eight years of use. Because the functional unit of the desk is “eight years of use”, the impacts of the production, use and disposal of the desk are distributed over that period of time. If the desk were redesigned (through a variety of design strategies) to last for ten years instead of eight years, the relative impacts of the desk would be reduced by (10 years – 8 years) / 10 years, or 20%. Strategies to improve the environmental performance of the desk include (among many others): exploring methods to cut and dry the boards with lower (or no) fossil fuel consumption, identifying ways to use the waste sawdust, and redesigning the desk to make it last more than eight years. The study indicates that alternatives to the use of fossil fuels to produce electricity to dry the boards offer the greatest potentials to improve the environmental and human health performance of the desks over their lifecycles.	
13	**Strengths and weakness of the whole study, general comments**	Strengths: analysis of FSC logs, improvement measures identified, sensitive analysis on lifespan of desks. Weakness point:: processes have been modelled with reference to Mexico.	$S_{ROBUSTNESS}$ = 3
14	**Subject to independent review?**	No Independent review.	S_{REVIEW} =1

TOTAL SCORE	S_{SCOPE}= 1 S_{DATA}=3 $S_{IMPACTS}$=5 $S_{OUTCOMES}$ = 1 $S_{ROBUSTNESS}$=3 S_{REVIEW}=3		**S_{TOTAL} = 16**
12	***Item***	***Observation***	***Scoring***
1	**title**	DONATI environmental awareness[106]	-
2	**authors**	DONATI	-
3	**reference and year**	Private documentation from industry, 2010	-
4	**type of study**	Complete LCA study according to PCR “Parts of furniture” (EPD international)	S_{SCOPE} = 1
5	**scope**	Assessment of different Chair bases made of aluminium (polished, polished and painted and painted aluminium) and nylon.	

<table>
<tr><td>6</td><td>functional unit</td><td>1 base ( ) during its average life time, (estimated being 15 years, as minimum.)</td><td rowspan="3"></td></tr>
<tr><td>7</td><td>system boundaries</td><td>Cradle-to-grave scope
The upstream processes include:
• extraction and production of raw materials for components and packaging;
• production of semi-manufactured materials;
• manufacturing process for components and packaging;
• all transportation involved;
• treatment of generated waste.
The core processes include:
• transportation of mechanism components and packaging to Donati;
• assembly of the mechanism including energy and water consumption at Donati;
• packaging of the mechanism;
• treatment of generated waste.
The downstream processes include:
• transportation of the mechanism to the customer;
• use of the product;
• end of life of the mechanism;
• end of life of the mechanism packaging.</td></tr>
<tr><td>8</td><td>assumptions (e.g. allocation)</td><td>Mass allocation for manufacturing.
The consumption data (water, energies, emissions, waste etc.) is aggregated for the same production site; therefore the Life Cycle Inventory has been based on allocation mass criteria (1 kg). The Life Cycle Impact results are expressed as functional unit (FU)</td></tr>
<tr><td rowspan="8">9</td><td>data sources and quality</td><td>The primary data is from DONATI company. Data process time for the manufacturing of the products is 2008. Primary data is used in most stages. Generic data of processes do not exceed 10% of the overall environmental impact due to the product. All LCI data comes from the Ecoinvent database (2009).</td><td></td></tr>
<tr><td>1. Raw materials</td><td>Data is based on suppliers . Data is “specific” and “selected generic”.</td><td>3</td></tr>
<tr><td>2. Manufacturing</td><td>Primary data is used and the data is collected on site. The electricity mix used by Donati is Italian. The data process time for the manufacturing of the products is 2008.</td><td>3</td></tr>
<tr><td>3. Distribution/ transportation</td><td>The vehicle type and the distances are based on real data provided for Donati and for supplying firms.</td><td>3</td></tr>
<tr><td>4. Use phase</td><td>-</td><td>-</td></tr>
<tr><td>5. Packaging</td><td>Primary data.
Packaging materials: cardboard, wood,plastic and iron</td><td>3</td></tr>
<tr><td>6. End of Life</td><td>For end of life treatment data is based on technique scenarios, hence selected generic data is used, assuming the best treatment (recycling) as the bases are a single material.</td><td>3</td></tr>
<tr><td>TOTAL</td><td></td><td>S_{DATA} = 3</td></tr>
<tr><td>10</td><td>Impact assessment categories/methods</td><td>CML characterization.
–global warming potential (GWP100); (Classification A)
–ozone layer depletion potential; (Classification A)
–acidification potential; (Classification B)
–photochemical oxidation; (Classification B)
–eutrophication potential; (Classification B)
–resource use (non-renewable and renewable) (not considered as key indicator)
–waste recyclable material; (not considered as key indicator)</td><td>$S_{IMPACTS}$ = 5</td></tr>
<tr><td>11</td><td>Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)</td><td>Using secondary aluminium, the energy consumed in the primary transformation is not lost, but stays incorporated in the metal, and is available again in the following recycling process. No other metal is considered as economical for recycling purposes as aluminium. For the die-casting of aluminium scrap only 5% of the original energy is used. The recycling of aluminium gives an energy saving of 95% which is the requirement for production at the raw material stage.
The impact distribution forpolished aluminium based is as follows:
<table>
<tr><th colspan="6">POTENTIAL ENVIRONMENTAL IMPACT OF POLISHED ALUMINIUM BASE (WEIGHT: 3.369kg)</th></tr>
<tr><th>IMPACT CATEGORY</th><th>UM</th><th>TOTALE</th><th>UPSTREAM MODULE</th><th>CORE MODULE</th><th>DOWNSTREAM MODULE</th></tr>
<tr><td>GLOBAL WARMING (GWP100)</td><td>kg CO_2 eq</td><td>16,9</td><td>10,6</td><td>4,5</td><td>1,8</td></tr>
<tr><td>OZONE LAYER DEPLETION (ODP)</td><td>kg CFC-11 eq</td><td>$1,9\cdot10^{-6}$</td><td>$1,3\cdot10^{-6}$</td><td>$0,4\cdot10^{-6}$</td><td>$0,2\cdot10^{-6}$</td></tr>
<tr><td>PHOTOCHEMICAL OXIDANT FORMATION (PO)</td><td>kg C_2H_4 eq</td><td>0,01</td><td>0,01</td><td>0,00</td><td>0,00</td></tr>
<tr><td>EUTROPHICATION</td><td>kg PO_4^{---} eq</td><td>0,04</td><td>0,03</td><td>0,01</td><td>0,0</td></tr>
<tr><td>ACIDIFICATION</td><td>kg SO_2 eq</td><td>0,08</td><td>0,05</td><td>0,02</td><td>0,01</td></tr>
</table>

Upstream module processes (materials processing) have the highest impacts in all impact categories, followed by core module (manufacturing). The downstream module has the lowest contribution.

Comparing different bases, aluminium bases show higher impacts than nylon bases for all impact categories. Results for Global warming are detailed in the following table:</td><td>$S_{OUTCOMES}$ = 1</td></tr>
</table>

The GWP100 (kg CO_2) for one functional unit is presented below.

Product	Upstream	Core	Downstream	Total
Polished Aluminium Base	10.6	4.5	1.8	16.9
Polished and painted aluminium	11	2.9	1.3	15.3
Painted aluminium	10.8	1.6	1.5	13.9
Nylon[1]	14.2	1,9	1.1	12.3

[1]The values represent the average for the different nylon bases, for more information about each base, se the full EPD®.

12	**Strengths and weakness of the whole study, general comments**	LCA performed according to PCRs and ISOs, and primary data used. Poor information on interpretation of results and no sensitive analysisAssessment for a chair component (base), not for the final product.	$S_{ROBUSTNESS}$ = 1
13	**Subject to independent review?**	Report for EPD. External verification by Certiquality S.r.l.	S_{REVIEW} = 5

TOTAL SCORE	S_{SCOPE}=3 S_{DATA}= 3 $S_{IMPACTS}$=1 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$=3 S_{REVIEW}=3		**S_{TOTAL} = 16**
13	***Item***	***Observation***	***Scoring***
1	**title**	Life cycle assessment of commercial furniture: a case study of Formway LIFE chair	-
2	**authors**	Gamage, G. B., Boyle, C., McLaren S.J., McLaren, J.	-
3	**reference and year**	Int J Life Cycle Assess (2008) 13:401–411	-
4	**type of study**	Attributional study according to ISO standards. Comparison of two models (aluminium base and glass-filled nylon (GFN) base). Sensitive analysis on waste-management scenarios and content of recycled aluminium. Consequential approach for recycling assessment (system expansion)	S_{SCOPE} = 3
5	**scope**	Chairs. New Zealand –Chair based aluminium: Aluminium 59.3%, Steel 9.1%, Glass filled nylon 6.3%, Polypropylene 0.8%, GFPropylene 0.3%, PUR 4.6%, POM (Acetyl) 1.8%, Acrylonitrile butadiene styrene 2.1%, Fabric 0.8%, Hytrel-crastin [polybutylene terephthalate (PBT)] 7.1%, PA6 (nylon) 2.2%, Packaging 5.7% -Chair base glass-filled nylon (GFN):Aluminium 49.8%, Steel 9.6%, Glass filled nylon 15.6%, Polypropylene 0.9%, Glass filled polypropylene 0.3%, PUR (polyurethane) 4.8%, POM (Acetyl) 1.9%, Acrylonitrile butadiene styrene 2.2%, Fabric 0.8%, Hytrel-crastin [polybutylene terephthalate (PBT)] 7.6%, PA6 (nylon) 2.3%, Packaging 4.2%	
6	**functional unit**	Provision of comfortable office seating, with the features stated in the product description, for a period of 10 years in line with the product warranty.	
7	**system boundaries**	Cradle to grave The inventory of inputs and outputs included the following stages: –Extraction of raw materials from the Earth's crust and subsequent refining to commercial quality –Utilisation of raw materials to manufacture components supplied by Formway's suppliers –Transportation of the components from the sites of manufacture to the Formway production facility in Wellington, New Zealand –Assembly and packaging of the LIFE chair –Transportation of manufactured products from Formway to the customer –Use phase and waste management	
8	**assumptions (e.g. allocation)**	The main inventory assumptions were: –Aluminium with the world average recycled content of 34%) was used for both the aluminium and GFN base chairs. –An average recycled content of 20% for steel components was used in both chairs (with validation from suppliers). –Polyethylene terephthalate, which was used as a proxy for Hytrel-crastin, is expected to display similar environmental effects as Hytrel-crastin. The recycling scenario was modeled by means of system expansion, assuming tht recylind of aluminium primary displaces aluminium production.	
9	**data sources and quality**	Data were collected directly from suppliers where possible. Where supplier data were unavailable, the ecoinvent v1.3 database was used. Some modifications have been applied to consider the right electricity grid mix.	
	1. Raw materials	Formway Suppliers information (audits/questionnaires). Ecoinvent for secondary data when needed.	*3*
	2. Manufacturing	Suppliers information for manufacturing of components and transport of components to Formay (by road) Data from Formway plant for assembly process (assembling requires electrical energy and manpower)	*3*
	3. Distribution/transportation	Average case for customers. –The customer was considered to be in Sydney, Australia, as this would represent an average-case scenario for transport.	*3*
	4. Use phase	No environmental exchange takes place during use of chairs since it does not require enrgy or water and it was assumed that no significant repairs are made during its life. The only need was cleaning, which includes wiping the surface to clear dust and is expected to have negligible impacts.	-
	5. Packaging		*3*

	6. End of Life	Ecoinvent. Two scenarios: i) the entire chiar is landfilled; ii) metal components are recycled and the remainder of the cuair is ladfilled. Trasnport of components to landfill/recycling facility is included.	*3*
	TOTAL		S_{DATA} = *3*
10	**Impact assessment categories/methods**	CML 2 baseline 2000 - global warming potential (GWP100) (Classification A)	$S_{IMPACTS}$ =1
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	The comparison of the two LIFE chair models showed that the GWP100 was higher for the model with the aluminium base than for the model with the glass-filled nylon GFN base. The results show that the main hotspot in the life cycle for both models is the raw-material extraction/refinement stage, mainly attributed to aluminium, an energy intensive material. Since contribution of aluminium was found to be significant, sensitive analysis was carried-out to evaluate the influence of recycled content (0%, 34%, 100%) on the results due to for aluminium with recycled contents. In all cases, the increase of recycled aluminium appeared beneficial because of the saving of resources and the avoidance of landfilling. Sensitive analysis in the end-of-life comparing landfill and recycling how clear advantage for recycling (considering system expansion)	$S_{OUTCOMES}$ =3
12	**Strengths and weakness of the whole study, general comments**	Sensitive analysis on recycled content of aluminium in the product (0%, 34%, 100%)	$S_{ROBUSTNESS}$ =3
13	**Subject to independent review?**	Publication in a peer-reviewed journal	S_{REVIEW} =3

TOTAL SCORE	S_{SCOPE}=1 S_{DATA}= 3 $S_{IMPACTS}$= 2 $S_{OUTCOMES}$ =3 $S_{ROBUSTNESS}$= 1 S_{REVIEW}=3		**S_{TOTAL} =14**
14	***Item***	***Observation***	***Scoring***
1	**title**	Environmental assessment of green hardboard production coupled with a laccase activated system.	-
2	**authors**	González-García, S., Feijoo, G., Heathcote, C., Kandelbauer, A., Moreira, T.	-
3	**reference and year**	Journal of Cleaner Production 19 (2011) 445-453	-
4	**type of study**	Consequential LCA (4 scenarios). The objective of this paper is to analyse the industrial process of green hardboard manufacture considering the substitution of the phenol-formaldehyde resin by a two-component adhesive with a wood-based phenolic material and a phenol-oxidizing enzyme (i.e. laccase). Additionally, the new product is compared to the one manufactured with the conventional PF resin used as the main bonding agent	S_{SCOPE} = 1
5	**scope**	Hardboard panel, domestic, Austria	
6	**functional unit**	1 m3 of finished green hardboard (using bio-adhesives) for interior applications. The board density is approximately 900 kg/m3 and its moisture content is 7% by weight.	
7	**system boundaries**	The study covers the life cycle of green hardboards production from a cradle-to-gate perspective, analysing in detail the hardboard plant and dividing the process chain in three subsystems: Fibers Preparation, Board Forming and Board Finishing. Auxiliary activities such as chemicals, bio-adhesive, wood chips, thermal energy and electricity production and transport were included within the system boundaries. The production and maintenance of capital goods were excluded for the two types of boards.	
8	**assumptions (e.g. allocation)**	An important feature of the wood-based industry is the simultaneous production of several products. For the panel industry, the main product is the panel, while residual wood is obtained as a byproduct. An allocation procedure is only necessary for the panels, since the residual wood is used for on-site generation of thermal energy. Forestwastewas taken into account to complete the energy balance of the biomass plant. No environmental burden allocation was assumed to forest waste from previous processes and only their transport and later processing were computed.	
9	**data sources and quality**	An Austrian hardboard plant, which has implemented the biotechnological process of green hardboards production, was selected to study the process in detail. LCI data were taken from Ecoinvent and ETH-ESU 96, 2004).	
	1. Raw materials	Other inventory data for the background system such as electricity, paraffin and aluminium sulphate production were obtained from the Ecoinvent database. Forest operation data taken from literature. The main raw materials are green wood chips obtained from Norway spruce (Picea abies) and European beech (Fagus sylvatica). This material is delivered by truck from Austrian woodbased industries such as sawmills, satellite chip mills, etc.	*3*
	2. Manufacturing	Inventory data for the foreground system (manufacturing) consisted of average data obtained by on-site measurements. It includes: fibers preparation, boards forming and boards finishings	*3*
	3. Distribution/transportation	-	-
	4. Use phase	-	-
	5. Packaging	-	-
	6. End of Life	-	-
	TOTAL		$S_{DATA=}$ *3*

10	**Impact assessment categories/methods**	CML 2 baseline 2000 V2.1 -Global warming (GW) (classification A) -acidification (AC) (classification B) -photochemical oxidant formation (PO) (classification B) -eutrophication (EP) (classification B) -cumulative energy (not considered as key indicator) (ozone depletion potential not considered in this study)	$S_{IMPACTS}$ =3
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	Fibers Preparation presented the highest contribution (more than 54%) to all the impact categories, followed by Board Forming and Board Finishing. This result was mainly due to the higher electricity consumption compared to the other subsystems and also to the laccase requirement. <u>Global warming potential</u> The Fibers Preparation subsystem contirbuted with83%. Electricity and laccase production for 39% and 31%. Fossil fuel consumption (mainly natural gas and hard coal) for electricity production accounted for more than 39% of the total contribution followed by the diesel requirement in wood chipping stage (17%). <u>Photochemical oxidants formation potential</u> The subsystem of Fibers Preparation had the largest contribution with 72%. Board forming and board finishing are responsible for 24% and 3%, respectively. Both laccase and on-site thermal energy production showed the highest contributions to this impact category (34% each). <u>Acidification potential</u> The Fibers Preparation and Board Forming subsystems were the most important contributors with 54% and 42%, respectively, followed by the subsystem of Board Finishing On-site thermal energy production was the main hot spot (63% of total contributions) due to the emissions of NOx and SO2 from the biomass boilers. <u>Eutrophication potential</u> Once again, the Fibers Preparation subsystem had the largest contribution to this impact category (61%) followed by Board Forming (36%) and Board Finishing (3%). The thermal energy plant was the main contributor to this impact category (55% of total), followed by laccase production (22%) and chipping stage (10%). The production of the phenolic compound contributed to 5% of total eutrophying emissions mainly due to COD emissions derived from the wastewater treatment plant in the biorefinery. The change from conventional HB to green HBs can reduce the contributions to almost all impact categories under study excluding EP, where the enzyme manufacture shows an important roledue to the large use of energy, as well as the carbohydrates (sugar and starch) and protein consumption in the laccase production process and the emissions of COD in the lignin based material production. The entire energy demand could be reduced by 45% since almost 30% of energy required in the subsystem of Wood preparation is associated to the production of laccase. Important reductions can be achieved regarding PO (it is possible to reduce the environmental profile up to 55% changing conventional HB to green HBs), in particular due to the avoidance of the emission of formaldehyde by means of the production and use of green bonding agents instead of PF. Normalisation was done for the green Hardboard system, obtaining the following results: 1. Hightly significant: AC 2. Significant: EP 3. Lightly significant: GW and PO The current green HB production process improves the environmental profile up to 18% in comparison with the conventional process using PF. Sensitive scenarios were done by improving the green process. The reduction in the dose of green adhesive (up to 25%) only improves the environmental profile by 19%. However, both reductions of 100% in the laccase and increases of 25% in the lignin material dose were also performed, and the normalized index could be reduced by 93% in comparison with the conventional process.	$S_{OUTCOMES}$ =3
12	**Strengths and weakness of the whole study, general comments**	Weakness: Cradle-to-gate assessment of a very specific and innovative board manufacturing technology.	$S_{ROBUSTNESS}$ =1
13	**Subject to independent review?**	Publication in a peer-reviewed journal	S_{REVIEW} =3

TOTAL SCORE		S_{SCOPE}= 3 S_{DATA}=0 $S_{IMPACTS}$= 1 $S_{OUTCOMES}$ = 1 $S_{ROBUSTNESS}$= 1 S_{REVIEW}=1	**S_{TOTAL} =7**
15	***Item***	***Observation***	***Scoring***
1	**title**	SUMMARY REPORT FOR LIFE CYCLE ASSESSMENT OF FURNITURE	-
2	**authors**	Indian Centre for Plastics in the Environment (ICPE).	-
3	**reference and year**	Unknown	-
4	**type of study**	Comparative study on PP, steel and wood. LCA study according to ISO 14040/44	S_{SCOPE} = 3
5	**scope**	PP furniture. The applications considered: Chair, Tables.	
6	**functional unit**	-The production, use and disposal of one chair for seating of one adult human. -One dining table as required for four persons.	
7	**system boundaries**	Cradle-to-grave. Included stages: - Raw material production - Furniture manufacture - Furniture transportation - Use of furniture - Used furniture management (Reuse/ Recycle/Disposal)The life cycle stages, processes and data not included : –Infrastructural requirements	

		–Manufacturing of chemicals not forming a part of the final product. –Transportation of materials by modes other than road. –Material inputs less than 1% of the total input. –Economic and socioeconomic parameters.	
8	**assumptions (e.g. allocation)**	Not detailed in the study	
9	**data sources and quality**	Not explained	
	1. Raw materials		-
	2. Manufacturing		-
	3. Distribution/ transportation		-
	4. Use phase		-
	5. Packaging		-
	6. End of Life	The modes of disposal studied include incineration and landfill.	-
	TOTAL		S_{DATA} = *0*
10	**Impact assessment categories/methods**	Ecoindicator 99 (H) -Human Health: Carcinogens, Respirable organics, Respirable inorganics, Climate change, Radiation,o Ozone layer - Ecosystem Quality: Ecotoxicity, Acidification, Eutrophication, Land use - Resources: Minerals, Fossil fuels	$S_{IMPACTS}$ =1
11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	From the normalization done, relatively-higher contributions are given for: respiratory inorganics, climate change and fossil fuel used, followed by acidification and eutrophication. In almost all cases, steel furniture has higher impacts, although PP consume more fossil fuels than steel and wood. Wood has higher impact values for climate change than PP, whereas for the rest of impacts PP shows higher values than wood furniture. **Wooden furniture:** Wooden furniture during its life cycle has an impact on Respirable organics and inorganics, Climate change, Acidification/Eutrophication, Land use and Fossil fuels. However the impact on Fossil fuels, Climate change and Land use is relatively high. As compared to PP furniture, wooden furniture has a lower impact on Resources but a higher impact on Human health and Ecosystem quality. Wood being a renewable resource does not have a major impact on resources. The impact during the manufacturing stage is primarily due to logging, transportation and incineration. Also, as compared to PP furniture, wooden furniture has less life resulting in higher environmental load during its life cycle. The other important aspect which has a major bearing on the final result is the release of carbon dioxide during the production stage. Non recyclability is a disadvantage that wooden furniture have vis-à-vis PP furniture. **Steel furniture:** Steel furniture have a relatively high impact on Respirable inorganics, Fossil fuels and Climate change while the impact on Minerals, Carcinogens and Respirable organics is low. As compared to PP furniture, steel furniture has a higher impact across all the three damage categories. The steel manufacturing process is resource intensive and the energy consumption during the transportation stage is also high. Steel manufacturing process involves the use of iron ore as a raw material, which is a non renewable resource. All these factors, combined together, result in a comparatively high score for the 'Resources' damage category. The steel manufacturing process also has a high impact on climate change, respiratory organics and carcinogens. The metal emissions during the steel manufacturing process results in high impact on ecosystem quality. **PP furniture:** The impact on Fossil fuel, Climate change and Respirable organics is comparatively higher than the other categories. As compared to the impact on Human health and Ecosystem quality, Polypropylene chairs, have a higher impact on the category 'Resources'due to the use of crude oil as a raw material and its use as a source of energy during the life cycle. Recycling of PP however, results in lowering the impact on resources. The PP Chair during its life cycle also results in high impact on respirable inorganics and acidification and eutrophication. PP being lighter tan steel and wooden furniture also has a lower impact during the transportation stage.	$S_{OUTCOMES}$ =1
12	**Strengths and weakness of the whole study, general comments**	Weakness: NO data on inventory source. Impacts at end-point-level. Geographic scope: India	$S_{ROBUSTNESS}$ =1
13	**Subject to independent review?**	No review	S_{REVIEW} 1

4.3.Critical review and summary on selected LCA and EPDs

13 out of 15 LCA studies satisfy the minimal quality requirements and have been analysed further.

In terms of functionality, the selected LCA cover the following types of furniture:

- One selected LCA paper refers to **wooden panels**: MDF (1)[123]
- Five LCA reports refer to **Office furniture**: desk (2)[98,107,] workplace (1)[108], table (1)[105], office chairs (5)[10598, 122] and base of chairs(1)[106], office divider panel (1)[98], operational table office (1)[98]
- One LCA report referring to **school** desk (1)[112]

- Five LCA reports covering **domestic furniture**: products: bed mattresses (2)[94], bed structure (1)[94], couch (1)[94], kitchen furniture (2)[94,104], table (1)[94], library (1)[94], childhood bedroom (1)[97], wardrobe (2), armchair (2)[98], nightstand (1)[98], showcase (1)[98], side table (1)[98]

It should be observed that the number of studies selected do not coincide with the number of case studies analysed, since several products may be addressed in a single report.

In terms of **scope**, office furniture and indoor domestic furniture are well covered. Some gaps of information are present for outdoor furniture, for which no specific and satisfactory studies have been identified. Information for this type of furniture should thus be complemented by referring to other studies focusing on issues like wood treatment for outdoor use. Most of the selected studies analyse a final furniture product while only two studies are focused on furniture components (panel board and a base of chair). Consequently, processing of materials and manufacturing of components are in some cases analysed with less detail than the core process of manufacturing (assembling) a piece of furniture.

In terms of **materials**, the main materials analysed in LCA studies are: wood, wood-based materials, metals and plastics. Most of the furniture studied are made of several materials:

- domestic furniture are usually made of wood or wood-panels,
- office chairs are usually made of metals (aluminium or steel) and plastics
- desks have as main component metal or wood-boards.
- Upholstering textiles used in seats (couches) are only covered by one study.
- glass is also present in some domestic furniture such as cabinets and libraries.

A specific LCA selected study[123], on wood-boards and studies on furniture using wooden boards[104,97] as components give useful information on potential environmental impacts related to the manufacturing and use of these panels. Regarding solid wood, some studies assess some issues such as forestry operations, certified management wood, as well as coatings of wood.

Metals are widely covered by studies, because the majority of office and domestic furniture studies have some components made of metals (mainly aluminium and steel). Some of them perform sensitive analysis on recycled content of metals and relative contributions of different types of metals such as steel and aluminium. Plastics are treated in some studies where some components are made of plastics, like all office wheel chairs. Nevertheless, not detailed analyses by type of plastics or recycled content are carried-out.

Regarding the goals and outcomes from studies, most of studies identify hot spots along the product life cycle. Some studies also perform sensitive analysis on different design options or do comparative analyses, which are detailed in the section *4.3.5 Analysis of environmental improvement* options.

EPDs were not assessed through the scoring methodology, apart when complete LCA studies for their elaboration were available. Nevertheless, they still form an important source of information for some parts of this section, as for the analysis of materials used in furniture and average composition (section 5.3.3).The EPDs gathered are the following *(see section 5.1.1. for more details)*:

- 5 EPDs on wooden panels/boards
- 25 EPDs on office chairs
- 4 EPDs on domestic chairs.
- 1 EPDs on table

Among the 13 LCA studies selected, 7 of them cover all life cycle stages from cradle to grave whereas the rest of them (6) have a scope from cradle to gate. Nevertheless, for most cradle-to-grave studies, the use stage is excluded from the system boundaries because considered to have very low contribution.

Regarding EPDs, almost all EPDs of chairs and tables are from cradle to grave (29 out of 30). The only exception is represented by the EPD for a chair which is based on a cradle-to-gate analysis. Nevertheless some EPDs do not cover end-of-life or use stage (see section 4.1.1 for more details).

For panels, 5 EPDs have a scope from cradle-to-grave, but they exclude use phase because impacts due to this stage are considered negligible. Only the emission of formaldehyde during use is reported in EPDs. For the end-of-life, valorisation in a biomass power plant with energy recovery is the scenario for all these EPDs.

Although the system defined depends on the type of furniture and materials used, the general flowchart for a typical furniture product can be drawn as follows:

-Upstream processes: extraction, processing and transport of raw materials. In some studies, manufacture of components is included in this stage.

-Core processes: manufacturing of furniture. It could include manufacturing of the different components or only their assembling. In the manufacturing stage, processes such as surface coating and the application of substances such as preservatives or flame retardants or glues and paints are considered. Packaging may be also included within this stage.

-Downstream processes: distribution, use, maintenance and end-of-life.

In particular, it is worth to observe that manufacture of components is alternatively included by some studies either in the upstream or in the core processes.Whereas information from companies and database are usually gathered for upstream and core process, downstream processes (end-of-life) usually refer to statistics and literature.When impacts of the use phase are included, maintenance and cleaning operations are considered. In most cases, only a simple cleaning operation (once a month) is considered.

Figure 32. General flowchart for furniture product systems (Source: own elaboration based on LCA studies)

UPSTREAM PROCESSES:

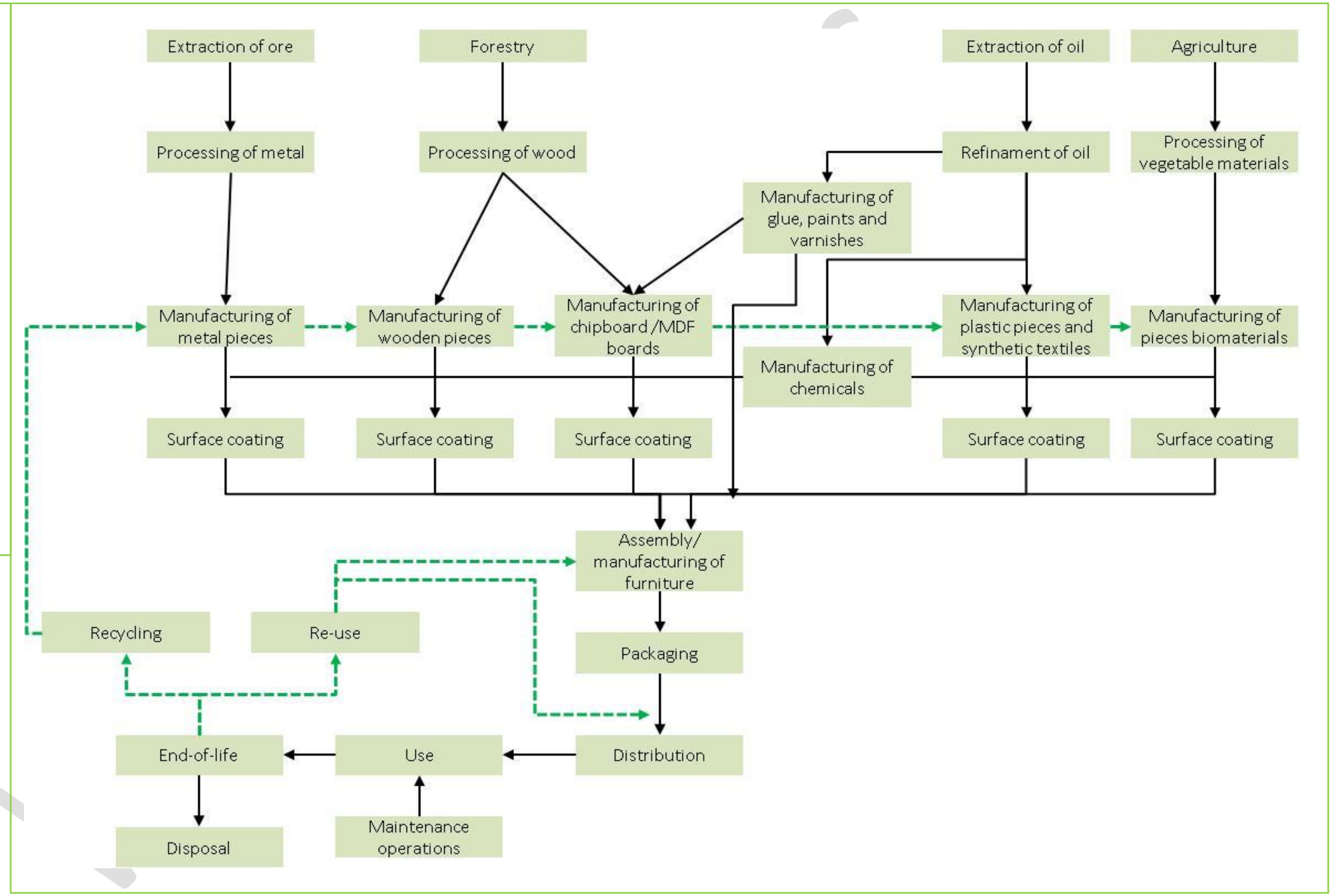
- Extraction of raw materials
- Transport of raw materials
- Processing of raw materials

CORE PROCESSES:

- Manufacturing of components
- Surface coating
- Assembly
- Packaging

DOWNSTREAM PROCESSES:

- Distribution
- Use
- End of life



4.3.1. Functional unit

The functional unit is the calculation basis used to quantify inputs and outputs of the inventory and the related environmental impacts. Ideally, the functional unit of furniture should relate to the use and the lifespan of each product. However, because of the diversity in types and applications of furniture, different approaches have been applied for the definition of the functional unit.

Product category rules (PCRs) documents for furniture establish guidelines on how to define the functional unit in an EPD. Functional units defined by PCRs are listed in the table below.

Table 21. Functional units defined in PCRs

Product group	PCR	Functional unit
General furniture	THE INTERNATIONAL EPD®SYSTEM. PCR BASIC MODULE CPC Division 38 FURNITURE; OTHER TRANSPORTABLE GOODS VERSION 1.1 DATED 2009-08-06	one unit of furniture or other transportable products
	THE INTERNATIONAL EPD®SYSTEM. Other Furniture VERSION 1.0 2012-05-08	one unit of furniture maintained during its life time
	THE INTERNATIONAL EPD®SYSTEM. CPC 38160 PARTS OF FURNITURE PCR 2009:01 VERSION 1.1 2010-02-25	one part of furniture during its life time
	Institut Bauen und Umwelt e.V. (IBU). PCR document "Wood-based materials", year 2009-11.	The declared unit is 1 m^3 of wood-based material. For coated panels or panels that are further processed (e.g. light construction panels) 1 m^2 can be declared instead.
	PRODUCT-CATEGORY RULES (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group Plate furniture NPCR 021. April 2012	One square meter of storage provided and maintained for a period of 15 years.
Chairs	THE INTERNATIONAL EPD®SYSTEM. UN CPC Class 3811: Seats PCR 2009:02 Version 1.0	seating provided and maintained for a period of 15 years
	Norwegian EPD Foundation. PRODUCT CATEGORY RULES (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group Seating solution NPCR 003 October 2013	seating provided and maintained for a period of 15 years
Cabinets	Product Category Rules (PCR) for System Cabinet PCR 2011:1.0 JIA WONG ENTERPRISE., LTD. (Taiwan). Version 1.0 2011-03-31	one unit of system cabinet for a product lifespan of 10 years
Bed solutions	Norwegian EPD Foundation. Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group Sleeping solution	one square meter of sleeping surface with a guaranteed lifetime of 15 years for the major components (approximately corresponding to 25 years)
Tables	Norwegian EPD Foundation. PRODUCT-CATEGORY RULES (PCR) for preparing an environmental Product Declaration (EPD) for Product Group Table NPCR 005 Revised version.	one square meter of table provided and maintained for a period of 15 years
Laminates	Institut Bauen und Umwelt e.V. (IBU). PCR document "Laminates", base year 2009.	1 m^3 of laminate
Upholstery textiles	Product Category Rules (PCR) for preparing an environmental Product Declaration (EPD) for Product Group Upholstery textiles Last revised: 17th November 2006	one square meter of textiles provided and maintained for a period of time.

In most of the PCRs related to furniture, the functional unit is one unit of product with indication of a definite or indefinite time reference (a certain amount of years or the product life time) during which a certain function must be provided. In general, the considered average lifetime is 15 years for seating solution, 10 years for cabinets, 15 years for sleeping solutions and 15 years for tables. For panels, the unit is generally proposed as volume (m^3).

Mainly three types of functional unit can be found in the literature:

- Units (i.e. pieces of furniture). This functional unit is usually considered for industry studies on specific furniture models. The lifespan of furniture can be even considered in the functional unit definition.
- Mass or volume. This functional unit is usually found in academic papers and in wooden boards or panels studies usually analysing different options. Lifespan is usually not considered and comparison among different furniture products and materials are not complete.
- Function (e.g. use of a chair for sitting with indication of the lifespan). This is considered the most coherent approach since it provides information about the furniture function and the technical life span.

The existence of different approaches makes it difficult to compare results from different studies, since the results are related to the functional unit chosen. Results must be analysed case by case and their potential correlations need to be evaluated carefully. Normally, no sensitivity analysis is done to evaluate how the functional unit choice can affect the results.

4.3.2. Inventory data and materials covered by LCA studies and impacts related

For the LCAs selected and the EPDs gathered, data inventory sources are detailed and the scheme can be summarized as follows by life stage.

- Upstream processes: raw materials extraction and processing, energy sources. This data is usually taken from suppliers but it is normally complemented with databases.
- Core process: manufacturing process, including packaging and sometimes distribution. This data is usually provided by manufacturers.
- Downstream processes: use and end-of-life. Whereas use phase usually does not include inventory data (only cleaning operation in some cases), end-of-life waste treatment stage is usually modelled based on statistics on waste management and databases.

Information about the composition of furniture, in terms of type and weight of the different materials are detailed in all selected studies and EPDs. The main materials analysed in LCA studies are: wood, wood-based materials, metals and plastics. Most of the furniture products studied are made of several materials. An average composition has been defined for main groups of furniture studying the composition of the different products available in the studies and can be found in Table 22.

Table 22. Average composition of representative furniture products

AVERAGE COMPOSITION OF CABINETS (arithmetic average of 3 products)	
Material	**Weight percentage**
wood	41%
wood panels	36%
glass	9%
metals	4%

plastics	0.4%
packaging	8.5%
others	2%
AVERAGE COMPOSITION OF DOMESTIC CHAIRS (arithmetic average of 3 products)	
Material	**Weigh percentage**
wood	69%
plastic	10%
Polyurethane (PUR)	9%
fabric	3%
packaging	9%
others	1%
AVERAGE COMPOSITION OF OFFICE DESKS (arithmetic average of 6 products)	
Material	**Weigh percentage**
wood	23%
wood panels	41%
metals	27%
plastics	1%
packaging	7%
AVERAGE COMPOSITION OF OFFICE CHAIRS (arithmetic average of 16 products)	
Material	**Weigh percentage**
Metal (alum.)	30%
Metal (Steel)	31%
plastics	17%
PUR	7%
fabrics	1%
Packaging	13%
Others	1%

4.3.3. Environmental impact categories and methods

In section 4.2.1, key environmental indicators were defined for furniture products, according to information from PCRs and literature. Environmental indicators found to be relevant for this product group are: Greenhouse warming potential, Ozone depletion potential, Acidification potential, photochemical ozone creation potential, Eutrophication potential.

All EPDs for furniture products (35) give information on these impact categories using the mid-point indicators required by the Product Category Rules which they refer to. The methods used are classified as A, B or C according to the overall classification provided in the ILCD Handbook[96.]. CML indeed uses IPCC method for GWP and WMO for ODP.

Regarding selected LCA studies, they usually cover all the impacts categories preliminarily identified, which can thus be considered the key environmental issues on which to focus. In most cases, the assessment methods used are those classified as A, B or C according to the overall scientific classification provided in the ILCD Handbook[96].

Regarding the 13 LCA studies selected, the impact methods used are the following:

- Six studies used CML 2000 or 1999 for 5 key environmental indicators:
  - Global warming potential (GWP): classification A. (kg CO_2 eq.)
  - Ozone layer depletion (ODP): classification A (kg CFC-11 equivalent)Acidification potential (AP): classification B. (kg SO_2 eq)

- ○Photochemical ozone creation potential (POCP): classification B (kg C_2H_4 eq)
- ○Eutrophication potential (EP): classification B (kg PO_4- eq)

- Fivestudies used CML2000 for global warming, acidification, photochemical ozone creation potential and eutrophication, but they use the Salomon, 1992, Nordic Guidelines for Ozone Layer Depletion.(kg CFC-11 equivalent).

  Some studies using this method impact, quantified also other indicators: abiotic depletion potential (kg Antimony eq.) (4 studies), human toxicity (kg DCB-eq.) (5 studies), ecotoxicity (kg DCB-eq.) (5 studies).

- One study[122] only calculated the indicator of global warming potential (GWP100) using CML method (classification A).

- One study from USA[114] used TRACI (midpoints indicators) and covered 2 out of the 5 key indicators:

  - ○Global warming potential (GWP): classification A (kg CO_2 eq)
  - ○Acidification potential (AP): classification E ((H+ mol eqv.)

  Other indicators were also considered, such as: Energy resource consumption (MJ), Citeria pollutants/human health (kg PM2.5 Eq), Solid waste (kg), total material consumption (kg).

Some studies using other methods have been excluded because they did not pass the cut-off criteria related to impacts categories.

4.3.4. Identification of key environmental impacts and hot-spots for furniture products

The review of the selected LCA studies and EPDs, allowed identifying environmental hot-spots along the lifecycle of furniture products, as described in the following.

In the table below, the impact distribution of products studied in selected studies are detailed. Note that in IHOBE studies, manufacturing stage include materials extraction and processing. In red it is marked the stage with higher contribution.

Table 23. Distribution of Global warming potential impact category for selected studies

Global warming potential

Furniture group	Study	materials				manufacturing	distribution	use	end-of-waste
		TOTAL	materials	packaging	transport				
Panels	Study 4 (MDF, UK)[99]	94,0%				5,5%			0,5%
Cabinets	Study 8 (Cabinet Martex, Italy)[103]	72,0%				28,0%			
	Study 7 (Cabinet Mascagni, Italy)[102]	61,0%				39,0%			
Kitchen	Study 9 (kitchen, Italy)[104]	40,0%				60,0%*			
Desks	Study 5 (Desk, Italy)[100]	96,0%				4,0%			
	Study 6 (Workplace, Italy)[101]	88,4%				11,6%			
	Wood desk IHOBE98					68,0%*	31,0%		1,0%
	Study 3 (IHOBE, Spain)[98]					94,0%*	60,0%		10,0%
Upholstered seats	Study 1 (PROPILAE, Fance)[94]	87,0%	85,0%	1,0%	1,0%	5,0%	4,0%		5,0%
Wood furniture	Study 1 (PROPILAE, Fance) (table, drawer, library)[94]	91,0%	81,0%	2,0%	8,0%	5,0%	3,0%		0,0%
	Study 11 (scholar desk, UNEP)[112]	71,3%				28,6%	0,1%		-0,1%
	Study 2 (Childhood set, Spain)[97]	49,0%				21,0%	13,0%		

Office wheel chair	Study 3 (IHOBE, Spain)[98]					89,0%*	9,0%		2,0%
	Study 3 (IHOBE, Spain)[98]					84,0%*	21,0%		-5,0%
	Study 13 (ALUMINIUM CHAIR Formway, New Zealand)[117]	63,5%	62,5%		1,0%	34,0%	0,5%		3,0%

**Note: in IHOBE studies, manufacturing stage include materials extraction and processing. In red it is marked the stage with higher contribution*

Table 24. Distribution of Eutrophication potential impact category for selected studies

Eutrophication potential

Furniture group	Study	materials				manufacturing	distribution	use	end-of-waste
		TOTAL	materials	packaging	transport				
Panels	Study 4 (MDF, UK)[99]	45%				3%			51%
Cabinets	Study 8 (Cabinet Martex, Italy)[103]	89%				11%			
	Study 7 (Cabinet Mascagni, Italy)[102]	77%				23%			
Kitchen	Study 9 (kitchen, Italy)[104]	70%				30%			
Desks	Study 5 (Desk, Italy)[100]	82%				18%			
	Study 6 (Workplace, Italy)[101]	97%				3%			
	Wood desk IHOBE98					65%*	33%		2%
	Study 3 (IHOBE, Spain)[98]					79%*	16%		5%
Upholstered seats	Study 1 (PROPILAE, Fance)[94]	61%	59%	1%	1%	1%	5%		34%
Wood furniture	Study 1 (PROPILAE, Fance) (table, drawer, library)[94]		36%	4%	27%	19%	10%		5%
	Study 11 (scholar desk, UNEP)[112]	49,1%				51,7%*	0,2%		-1,0%
	Study 2 (Childhood set, Spain)[97]	55%					13%		
Office wheel chair	Study 3 (IHOBE, Spain)[98]					85%*	14%		1%
	Study 3 (IHOBE, Spain)[98]					68%*	30%		2%

**Note: in IHOBE studies, manufacturing stage include materials extraction and processing. In red it is marked the stage with higher contribution*

Table 25. Distribution of Acification potential impact category for selected studies

Acidification potential

Furniture group	Study	materials				manufacturing	distribution	use	end-of-waste
		TOTAL	materials	packaging	transport				
Panels	Study 4 (MDF, UK)[99]	89%				11%			1%
Cabinets	Study 8 (Cabinet Martex, Italy)[103]	79%				21%			
	Study 7 (Cabinet Mascagni, Italy)[102]	72%				27%			
Kitchen	Study 9 (kitchen, Italy)[104]	45%				55%*			
Desks	Study 5 (Desk, Italy)[100]	75%				25%			
	Study 6 (Workplace, Italy)[101]	95%				5%			
	Wood desk IHOBE98					64%*	35%		2%
	Study 3 (IHOBE, Spain)[98]					89%*	8%		2%
Upholstered seats	Study 1 (PROPILAE, Fance)[94]	100%	1%	1%	2%	5%		-8%	100%
Wood furniture	Study 1 (PROPILAE, Fance) (table, drawer, library)[94]	79%	38%	2%	39%	12%	14%		-5%
	Study 11 (scholar desk,	52,5%				67,5%*	0,2%		-20,2%

Furniture group	Study	TOTAL	materials	packaging	transport	manufacturing	distribution	use	end-of-waste
	UNEP)[112]								
Office wheel chair	Study 2 (Childhood set, Spain)[97]	45%							
	Study 3 (IHOBE, Spain)[98]					91%*	9%		0%
	Study 3 (IHOBE, Spain)[98]					73%*	23%		4%

**Note: in IHOBE studies, manufacturing stage include materials extraction and processing. In red it is marked the stage with higher contribution*

Table 26. Distribution of Ozone layer depletion potential impact category for selected studies

Ozone layer depletion potential

Furniture group	Study	materials TOTAL	materials materials	materials packaging	materials transport	manufacturing	distribution	use	end-of-waste
Panels	Study 4 (MDF, UK)[99]	84,1%				14,8%			1,1%
Cabinets	Study 8 (Cabinet Martex, Italy)[103]	98,0%				2,0%			
	Study 7 (Cabinet Mascagni, Italy)[102]	84,0%				16,0%			
Kitchen	Study 9 (kitchen, Italy)[104]	90,0%				10,0%			
Desks	Study 5 (Desk, Italy)[100]	85,0%				15,0%			
	Study 6 (Workplace, Italy)[101]	99,8%				0,2%			
	Wood desk IHOBE98					73%*	24%		4%
	Study 3 (IHOBE, Spain)[98]					84%*	14%		2%
Upholstered seats	Study 1 (PROPILAE, Fance)[94]	84%	75%	1%	8%	1%	29%		-14%
Wood furniture	Study 1 (PROPILAE, Fance) (table, drawer, library)[94]		100%	0%	0%	0%	0%		0%
	Study 11 (scholar desk, UNEP)[112]	100%				negative values	-		negative values
Office wheel chair	Study 2 (Childhood set, Spain)[97]	57,0%	46,0%		11,0%		23,0%		
	Study 3 (IHOBE, Spain)[98]					82%*	17%		2%
	Study 3 (IHOBE, Spain)[98]					60%*	36%		4%

**Note: in IHOBE studies, manufacturing stage include materials extraction and processing. In red it is marked the stage with higher contribution*

Table 27. Distribution of Photochemical oxidant creation potential impact category for selected studies

Photochemical oxidant potential

Furniture group	Study	materials TOTAL	materials materials	materials packaging	materials transport	manufacturing	distribution	use	end-of-waste
Panels	Study 4 (MDF, UK)[99]	91%				8%			1%
Cabinets	Study 8 (Cabinet Martex, Italy)[103]	81%				19%			
	Study 7 (Cabinet Mascagni, Italy)[102]	12%				88%			
Kitchen	Study 9 (kitchen, Italy)[104]	36%				65%			
Desks	Study 5 (Desk, Italy)[100]	78%				23%			
	Study 6 (Workplace, Italy)[101]	96%				4%			
	Wood desk IHOBE98					71%*	28%		1%
	Study 3 (IHOBE, Spain)[98]					97%*	2%		0%
Upholstered seats	Study 1 (PROPILAE, Fance)[94]	51%	49%	1%	1%	45%	5%		-1%
Wood furniture	Study 1 (PROPILAE, Fance) (table, drawer, library)[94]		26%	0%	3%	69%	1%		0%

	Study 11 (scholar desk, UNEP)[112]	98,7%				2,5%	0,0%		-6,3%
	Study 2 (Childhood set, Spain)[97]	63,0%							
Office wheel chair	Study 3 (IHOBE, Spain)[98]					93%*	6%		0%
	Study 3 (IHOBE, Spain)[98]					88%*	13%		-1%

**Note: in IHOBE studies, manufacturing stage include materials extraction and processing. In red it is marked the stage with higher contribution*

➢**<u>DISTRIBUTION OF IMPACTS ALONG LIFE STAGES AND IDENTIFICATION OF HOT-SPOTS</u>**

This distribution of the impacts is in general similar in all the studies analysed.

Environmental impacts of furniture products are mostly associated to the production and the further treatment of the raw materials used in the manufacture stage (this is common for all LCA studies selected). Contribution of materials can vary between 72-90% according to the IHOBE Sectoral Guide[98] and it can be still more significant, depending on the piece of furniture evaluated.

Production of the furniture, mainly consisting of components assembling, is usually the second most important stage in terms of environmental impacts (6-20% according to a study)[98]. Magnitude of impacts is significantly lower than for materials and mainly due to consumption of energy (for instance drying step in painting and coating)[109],[110] and to the use and emission of substances in the finishing processes.[94,121, ,103,102,100 104,117]

Contribution from product transport and disposal is minor (1-15% and 1-4%, respectively[98,] according to a study), and dependent on the assumption considered for distance and mean of transport for waste disposal scenario. Reuse of the product can present significant advantages. According to some studies, product transport and end-of-life can be of concern, from a lifecycle perspective, for ODP[97] and eutrophication[94], respectively.

It is generally registered that the impact due to raw materials is lower for wooden furniture than for products containing higher amounts of metal parts[114,94]. Consequently, manufacturing and transport assume relatively higher importance. However, it must be observed that materials can offer different performances in terms of durability.
When included in the assessment, it was shown that impacts of the use phase are for negligible.[94,98]

In the table you can find the average distribution of impacts among the different life cycle stages by each impact category. It can be seen that materials have the highest contribution in all impact categories, followed by manufacturing, distribution, end of life and use phase.

Table 28. Average life stages contribution for the different impact categories

	Materials	Manufacturing	distribution	use	end-of-waste
Global warming potential	Average: 74% Min.: 40% Max.: 96%	Average: 30% Min.:4 Max.:89	Average: 10% Min.: 0.1% Max.: 31%	Average: Min.: Max.:	Average: 1% Min.: -5% Max.: 5%
Eutrophication potential	Average: 71% Min.: 45 Max.: 97	Average: 18% Min.: 3% Max.: 51,7%	Average: 15% Min.: 0.2% Max.: 33%	Average: Min.: Max.:	Average: 12% Min.: -1% Max.: 51%
Acidification potential	Average: 69% Min.: 45 Max.: 95	Average: 15% Min.: 2 Max.: 27,3,	Average: 13% Min.: 0.2% Max.: 35%	Average: Min.: Max.:	Average: 3% Min.: -20.2% Max.: 4%
Ozone layer depletion	Average: 85%	Average: 7%	Average: 18%	Average:	Average: 0%

potential	Min.: 57% Max.: 99.8%	Min.: 0% Max.: 16%	Min.: 0% Max.: 36%	Min.: -14% Max.: 4%	Min.: Max.:
Photochemical oxidant potential	Average: 69% Min.: 12% Max.: 98.7%	Average: 36% Min.: 2.9% Max.: 88%	Average: 8% Min.: 0% Max.: 28%	Average: Min.: Max.:	Average: 1% Min.: -6% Max.: 1%

Note: studies where the manufacturing stage includes processing of materials have not been included for the elaboration of this table.

Different studies on wooden furniture[111],[104] show that the production of wooden boards is an energy intensive process that constitutes the main hot-spot of the lifecycle. Board sawing and drying stage form the largest contributions to the environmental impacts[,112,97,113]. Positive effects can be achieved through reuse of production waste in place of virgin fibres or through energy recovery[121]. Transport of wood raw materials can contribute significantly (above 50%) to the greenhouse emissions generated during the lifecycle of a piece of furniture when origin of wood or costumers are far from the production facility.

Apart from the 5 key indicators selected for the screening, it was found that some additional sources of concerns in the lifecycle of wooden furniture can be represented by the system of chemicals used[94,97,102,104,105]. For instance, significant levels of toxicity can be associated to the use of some resins[94,97] , such as alkyd resins[94] and urea-formaldehyde resins[114]. A significant contribution to POCP can also result from some finishing processes[94], such as aromatic-diluents based lacquering)[104], use of solvent based on xylenes, use of naphthene and toluene for polyurethane finish and UV coating, emissions from paints and varnishes, fillers and diluents[102]. The use of acrylic adhesives in chipboards could be instead significant for ODP.[103]

In other types of furniture it is possible to appreciate that also other materials can have a significant weight in terms of environmental impacts. This is the case of textile materials in upholstery furniture[94] and component made of metal, especially when virgin metals are used[100,103,105,106,117.] Some plastics can also be included within the hot-spot of the furniture lifecycle, such as: ABS for edge and panel boards, contributing to ODP,[101] PVC and PVA, contributing to ODP.[104] With respect to packaging, its contribution is estimated being 6%, on average, in a studies where packaging impact is detailed[100,101,102,103,104].

➢ **UPSTREAM PROCESSES: MATERIALS AND COMPONENTS PRODUCTION**

As described above, main consumptions and impacts are due to the production of components.

In **furniture made of mixed materials** (metals, plastics and wood-based panels), contributions of production and transport of components in the selected indicators is: 85-96% for global warming, 85% for ozone depletion, 77-95% for acidification, 82-97% for eutrophication, 77-95% for photochemical ozone formation.

For furniture made of mixed materials, aluminium was found to have the highest ratio impact/weight, in comparison with other materials such are wood-based panels:

- Relative impacts from primary aluminium when forming 39.9% by weight of the furniture: 90% of energy consumption, 85% of global warming, 81% of acidification[100].
- Relative impacts from primary aluminium when forming 25% by weight of the furniture: 60% of energy consumption, 84% of global warming, 81% of acidification[101].
- Relative impacts from primary aluminium when forming 13% by weight of the furniture: about 47% of energy consumption, 65% of climate change[103].

Using secondary aluminium, the energy consumed in the primary transformation is not lost, but stays incorporated in the light metal, and is available again in the following recycling process. No other metal is as economical for recycling purposes as aluminium. All studies performing sensitive analysis on aluminium show significant benefits associated to the use of secondary aluminium. Secondary aluminium can allow reducing the energy consumption by 89-95% (145 MJ/kg for primary aluminium and 15.9 MJ/kg for recycled aluminium)[100]. In a study on office furniture[114], increasing the content of secondary aluminium by 10% was found to reduce global warming by 54% and the acidification potential by 62%.

Plastics such as PVC, PVA and ABS have a high energy demand and have high contribution in Ozone depletion Potential category.

Wooden panels and boards are normally used as component for finished furniture. Consequently most of furniture studies include the manufacturing process of panels in upstream processes. For furniture where **wood and wood-based panels**[104,94] are the main component, materials stage has a lower relative contribution: 61% of global warming, 84% of ozone depletion, 45-72.7% of acidification, 70-77% of eutrophication. For energy consumption the contribution is 67-73.3%.

LCA results vary significantly among types of wooden boards and manufacturers with up to 50% variance of environmental impact indicators among the different studies. The variance is connected to the type of material, density of panel, and energy efficiencies of the production process as well as to the different sources of energy used.

For most impact categories, the fibre production stage has the highest environmental impact (54% on average, depending on the impact category) due to energy use and chemical additives used in fibre preparation. Sensitive analysis showed that highest potential of reducing impacts from panels are: the use of recycled fibres and the reduction of use of non-renewable resins[99].

In general terms, the following conclusions can be extracted from LCA studies[123] and EPDs for panels. The average contribution to the selected impact categories is as follows:

- The greenhouse warming potential is the impact category more significant for wooden panels. Most of the climate change impact is associated with the production stage, since raw materials (wood/paper) are carbon neutral materials with respect to the feedstock.
- Raw materials (approximately 25–85%) and production (20–75%) are the main contributors for the ozone depletion potential.
- Raw materials (about 30–80%), production (about 15–55%), transportation (about 8–20%) and EoL (about 20%) are the main contributors for the acidification potential.
- Raw materials (40-90%), production (9-50%), transportation (6%) and EoL (around 20%) are the main contributors to the eutrophication potential.
- Raw materials contribute approximately 25-80%, production (15-70%) and transportation (5%) to the photochemical oxidant creation potential.

Packaging materials are included in some studies in materials stage. Packaging contributes on average in 6% of materials' impact.

The use of different materials for the same application has been object of some comparative analyses for the same type of furniture and function. Wood, especially if sourced from sustainable harvesting practices, has been shown to be the best material for use in many different applications as it has lower impacts on the environment compared to other materials such as metals and plastics for the same applications[115]. Comparing to metals and plastic, wooden materials were found to be the least energy intensive[116]. Because of this, they score less for most of the impact categories studied, such as global warming or acidification. It is also important to highlight that timber is a renewable resource in comparison to other materials such as metal or plastic. Nevertheless, wooden materials have higher impacts for human health and ecosystems quality when comparing to plastic materials due to substances used in the processing of the fibres and the panels.

Regarding plastics, studies show that some plastics used in furniture such as Glass-Filled Nylon GFN[117] or Polypropylene show better environmental performance where they are compared to metals (steel and aluminium) for the same applications and functions. Main impacts from plastics are due to the use of oil as a raw material and as a source of energy. Being lighter than steel and wooden furniture, plastics have also a lower impact during the transportation stage[118].

In all studies where metals are present, they have the highest impacts per weight, basically due to the fact that they are very intensive energy materials. Primary aluminium is the metal more intensive energy compared to other plastics like steel.

One of the determinant parameter conditioning the environmental behaviour of materials is the embodied energy. From a study review of EPDs office seating solution[119] it was concluded that potential impacts of categories like Global Warming Potential, Eutrophication Potential, Acidification Potential and Heavy Metals have a strong correlation with energy consumption data of EPDs for seating solutions. In the table below it can be seen that wood have relative low energy demand comparing to other materials, whereas aluminium is the most energy demanding material.[120]

Table 29. Energy embodied in some materials used in furniture (average and indicative values)[120]

Material	Embodied Energy in Materials (MJ/kg)
Aluminium	170.0
Plastics (general)	90.0
PVC	80.0
Galvanised mild steel	38.0
Mild steel	34.0
Glass	12.7
Medium Density Fibreboard (MDF)	11.3
Glued-laminated timber	11.0
Laminated veneer timber	11.0
Plywood	10.4
Particleboard	8.0
Kiln dried sawn softwood	3.4
Kiln dried sawn hardwood	2.0
Air dried sawn hardwood	0.5

Transport of raw materials

One source of environmental impact of materials is the geographic origin of these materials, since transport associated from origin to manufacturing plant can be significant. Some of the raw materials that can be imported from long-distance sites are: tropical wood or metals, among others. Transport of raw materials from the site of extraction/processing to the assembly plant can have contributions going to 1% to 39% depending on the impact category and the origin of raw materials (see *Table 23,Table 24,Table 25,Table 26,Table 27*). Measures to decrease the environmental burdens due to transport are provided in Section 4.3.5. One of the most effective measures could be to prioritize local suppliers.

➢ **MANUFACTURING STAGE**

For a final furniture product, manufacturing consists basically in the processes of finishing and assembling different components. This stage has lower contribution than material processing (around 10%, depending on the impact categories for the selected studies). For the manufacturing, the main contributions in all impact categories are due to energy consumption (electricity and heating). However, also the use of chemical is one of the hot-spots.[99,100,101,102,103,104,105,106,111,112,117]

Manufacturing processes with higher contributions are those including treatment of materials (such as surface coating, glueing, etc) which require chemicals and energy. Coating processes can demand high amonuts of electricity and heat for drying (up to 70% and 78% of total energy demand and GWP of the manufacture process, respectively).[100,101,102,103,104]

Lacquering process has also relevant impacts for the presence of aromatic diluents, particularly in Photochemical Ozone Creation Potential category.

For furniture products where coating is applied[102], core processes have the highest contribution on photochemical ozone formation, (more than 80%), mainly due to atmospheric emissions resulting from the coating systems (emission of solvent in paints and varnishes, fillers and diluents). Substances with especial contribution are: solvents base of xylene contained in the products of the application of the polyurethane finish, naphthenes due to the presence of cycle primarily alkanes in the products of UV coating, toluene as a diluent in paint products, both UV and polyurethane-based..

➢ **DISTRIBUTION**

Distribution of the final product to the end user is modelled in some studies, with data from manufacturer and sales statistics. This stage is in general less significant from a life cycle perspective than materials or manufacturing since on average it has a contribution of 8-18% depending on the impact category. Sensitive analysis however shows improvement potential if efficiency measures on distribution are applied (such as promote efficient vehicles or regional distribution with shorter distances).[97]

Transport activities are especially important in terms of Ozone Depletion Potential (18% of contribution on average) due to tailpipe emissions from trucks. Moreover, consumption of heavy fuel oil is characterized by significant emissions of nitrogen oxides responsible for the Acidification Potential (13% on average) and Photochemical Oxidant Creation Potential and Global warming potential (see Table 26).

➢ **USE**

Use stage does not seem to contribute appreciably to the environmental impacts. In those studies where cleaning or maintenance operations are considered, impacts of this stage are not relevant (1-2% approximately) [94]. For upholstered furniture, sensitive analysis on cleaning operations showed a variance of 0.5% for all indicators.[94]

Durability of furniture is an important parameter since it will determine the lifespan. Sensitive analysis on lifespan showed significant reductions of impacts by increasing durability. For instance, increasing the lifetime of a desk from 8 to 10 years would decrease impacts by 20%[121].

For panel boards and furniture made on wooden panels, indoor emissions of VOCs (especially formaldehyde) can be significant, although this effect is not reflected in LCA studies since the LCA studies analysed did not assess indoor emissions.

➢ **END OF LIFE**

The End of Life can be responsible for relevant impacts in some furniture products (around 5% on average, but it can have higher values depending on the end-of-life scenarios).

In all studies where different waste treatment scenarios were compared, options to recover value from the product after use seems to be feasible and to offer great possibilities to reduce the environmental impacts.

For instance, reuse of components can dramatically reduce impacts by avoiding the production of other new units. A LCA study[122] qualitatively shows that recycling of furniture can decrease the GWP100 in comparison to landfilling. Also the reuse of wood waste as secondary material or for energy purposes was found to produce significant environmental benefits compared to the disposal in landfill[123]. This applies to both the final product after its use and to the waste produced along the production chain.

4.3.5. Analysis of environmental improvement options

Some selected studies performed streamlined sensitive analysis on different parameters (e.g. content on specific substances, percentage of recycled materials, distribution distance) in order to quantify the environmental improvement potential offered by some design options.

The Spanish Ecodesign Guide[98], identified a broad set of ecodesign options to be potentially applied in the furniture sector, based on results obtained in the LCA studies of representative furniture. In the guide document, for each eco-design measure, the technical, economic and environmental implications are detailed as well as examples of its application.

Main results are summarized for each life stage in the table below. A comprehensive list of potential environmental improvement measure for each life stage is shown, estimating its environmental improvement potential (high; medium; low) and technical feasibility (high: change with no technicial implications in process/technologies; medium: feasible since alternatives exist in the current market but the measure implies changes/adaptation in processes; low: possible but few or experimental alternatives exist and adaptations can imply tecnicial limitations and sobrecosts). For each measure, results of sensitive analysis performed in the selected LCA studies are detailed when available.

Life Cycle Stage	Strategy	Measure[98]	Environmental improvement potential (high, medium, low)[98]	Technical feasibility (high, medium, low)[98]	Sensitive analysis done in selected LCA
RAW MATERIALS	**STRATEGY: Selection of materials with low environmental impact.**	Use materials and production processes with low energy consumption associated.	High	Medium	
		Select suppliers close to the place of manufacture of the product.	High	High	
		Avoid the use of halogenated flame retardants.	High	Medium	
		Wood: Avoid the use of wood from protected species and use wood produced in forest plantations	High	High	
		Use wood and wood fibres from sustainable sources. (Wood)	High	High	
		Use wood without chemical or dangerous treatment. (Wood)	High	High	
		Use wooden boards with low VOC emissions. (Wood)	High	Medium	Sensitive analysis on the amount of resin content in wooden panels. Decreasing the mass contribution of urea-formaldehyde resin from the current level of 9.5% to 4.9% in particleboard composition results in reductions for all key categories (20% of global warming, 58% of acidification potential)[105]
		Use boards with low formaldehyde emissions. (Wood panels)	High	Medium	
		Using recovered and recycled wood. (Wood boards)	High	High	Several studies on panels performed sensitive analysis on the effect of reducing the total demand of virgin fibres by using recycled fibres. Studies showed that increasing the percentage of recycled fibres content allow higher environmental impacts reductions (specially with higher percentage, where the benefits from recycling are higher than the energy used for recycling process, and net benefit are higher that incineration with energy recovery). For the case of MDF panels, there is a potential reduction of 0.52 tones of CO_2 eq. per tone of rMDF produced[124].
		Use recycled plastics. (Plastics)	High	Medium	Promotion of recycled plastic materials in a childhood set wooden furniture[97]: Two scenarios were considered: 1) use of recycled plastic for the 100% of the weight of the sleeping base and legs was proposed, and 2) use of recycled plastic only for the 50% of these parts. The environmental index (sum of the 10 impacts of CML normalized for Western Europe) decreased slightly (0.05% and 0.03% respectively) although remarkable reductions can be achieved for Acidification Potential and Photochemical Oxidant Formation Potential.
		Use recyclable plastics. (Plastics)	High	High	
		Eliminate dangerous plastics additives. (Plastics)	High	Medium	
		Use recycled-sourced metals. (Metals)	High	High	Sensitive analysis on the content of recycled aluminium[125,126] confirm that the use of aluminium with high recycled content was beneficial; since production of recycled

					aluminium is less energy intensive than production of primary aluminium (only about 5% of the energy required to produce the primary metal initially is needed in the recycling process[127])[128],[104] These energy savings bring important environmental savings for furniture products. For office furniture[129]. per every one percent increase in recycled content, the reduction in the different impact categories was: 0.54% of reduction in Global Warming Potential, 0.56% of energy reduction, 0.62% of acidification potential.
		Use recyclable metals. (Metals)	High	High	
		Use paints and varnishes without organic solvents. (Paints / Varnishes)	High	Medium	
		Avoid the use of toxic substances in foams padding. (Foams)	High	Medium	
		Limit the use of chrome tanned leather. (Leather)	High	Low	
		Use natural materials for the manufacture of textiles. (Textiles)	Medium	Medium	
		Use recycled materials in the manufacture of polymeric textiles. (Textiles)	Medium	Low	
		Avoid the use of toxic or hazardous chemicals to the environment in textiles. (Textiles)	High	Medium	
		Use of biodegradable and low-toxicity lubricants. (Lubricants)	Medium	Medium	
		Use recycled glass. (Glass)	High	Medium	
		Reduce the percentage of lead and / or copper metal coatings of glass mirrors. (Glass)	High	Medium	
	STRATEGY: Reduce the use of materials	Design components for a lower amount of material.	High	Medium	Optimization of the amount of materials used in a childhood set wooden furniture[97]: As the production of the wooden materials was identified as the main hot spot in all the impact categories under assessment, the strategy focused on the reduction of the thickness of the wooden boards (from 35 mm to 30 mm). The environmental index (sum of the 10 impacts of CML normalized for Western Europe) decreased by 7.2%.
		Use lighter materials	Medium	Medium	
MANUFACTURING	STRATEGY: Select production techniques environmentally efficient	Designing products to use the minimum number of production stages.	Medium	Medium	
		Avoid the use of adhesives or additives containing heavy metals and their compounds.	High	High	
		Use solvents reused. (Paints / Varnishes)	High	Low	
		Avoid the use of toxic or hazardous chemicals to the environment in assembly adhesives. (Adhesives)	High	Medium	
		Avoid using adhesives with alkylphenol, alkyl or	High	Medium	

		halogenated solvents. (Adhesives)			
		Limit the content of VOCs in adhesives used in the assembly. (Adhesives)	High	Medium	
		Improve enrgy efficiency and promote the use of renewable energy	High	Medium	Use of renewable energy in the manufacturing of a childhood set wooden furniture[97]: 7% of the total electricity consumption from photovoltaic. Electricity is taken from the Spanish national grid which depends considerably on fossil fuels. The environmental index (sum of the 10 impacts of CML normalized for Western Europe) decreased by 2.1%, highest reductions for acidification potential, freshwater and marine aquatic ecotoxicity.
					Minimization of energy use in the manufacturing of a childhood set wooden furniture[97]: decreasing by 20% the energy use during the manufacture process allows a reduction by 5.4% of the environmental index impact (sum of the 10 impacts of CML normalized for Western Europe).
					Re-use of production waste for the manufacture of other products. The on-site re-use of 1% (strategy 2a), 2.5% (strategy 2b) and 4% (strategy 2c) of the waste generated in the production process.The highest reductions are achieved in categories such as ODP, HTP and PE since these categories are considerably influenced by contaminant substances derived from the board production (such as fluorides and CFC).
					For the manufacturing of wood desks[121], it was found that alternatives to the use of fossil fuels to produce electricity to dry the boards offer the greatest potentials to improve the environmental and human health performance of the desks over their lifecycles.
DISTRIBUTION	Select efficient distribution systems	Design the product to take up little space in storage and transportation.	Medium	Medium	
		Minimize the use of packaging.	Medium	Medium	
		Use reusable or returnable packaging.	Medium	Medium	
		Use recyclable packaging.	High	High	
		Using recycled packaging materials.	High	High	
		Use packaging materials with low environmental impact.	High	High	Childhood set wooden furniture[97]Substitution of plastic bags used for packaging with cardboard as well as reduction of the amount of plastic bags (three scenarios considered: 10%, 20% and 30% of reduction). The highest reduction corresponds to the alternative based on the total substitution of plastic bags by cardboard. This reduction (specifically in categories such as Abiotic Depletion Potential, Acidification Potential and Eutrophication Potential) is due to the less energy and fossil fuel requirements in the production process of the cardboard instead of the plastic bags.
		Use of naturally occurring biodegradable polymers in the packaging.	High	Medium	
		Use mono-material packaging.	High	High	

		Avoid the use of halogenated plastics in packaging.	High	High	
		Require reusable or returnable packaging suppliers.	High	Medium	
		Adhere to a rental system and reuse packaging.	High	Medium	
		Select a transport system for the distribution of the product with low environmental impact.	Medium	Medium	Childhood set wooden furniture[97]: Prioritize the use of Euro V vehiclesSubstitution of Euro 4 trucks and vans (used for the delivery of material inputs, waste and final product distribution) with Euro 5 ones. Reducing the environmental burdens associated to the transport processes specifically in categories such as Acidification Potential, Eutrohpication Potential and Human Toxicity Potential due to lower NOx, barium and cadmium emissions. On the contrary, in other categories the environmental burdens were increased but lightly, e.g. up to ~0.3% the CO_2 emissions.
		Optimizing the design of delivery routes.	Medium	Medium	A sensitivity analysis has been performed in the French study[130] on covering different furniture products, different sensitive analysis are performed regarding distribution: o Influence of the location where of fabrication of some components are produced. For upholstered furniture[130], sensitive analysis was done for the nature of textile and site of fabrication of textile/cover. It showed that air acidification is a sensitive indicator of transport of textile, but has low variation in general due to the low weight of cover regarding all furniture. o Influence of the location where of fabrication of the final furniture product is manufactured (not only the components, but the entire product).
USE	STRATEGY: Reduce the environmental impact during use	Inform the user about the proper use and maintenance.	Medium	High	
		Design the product for easy cleaning.	Medium	High	
		Minimizing energy consumption during the use stage (furniture energy consumers).	Medium	High	
		Facilitate removal of the product components.	Medium	High	
	STRATEGY: Optimize the life cycle	Designing the product taking into account their entire life cycle.	High	High	
		Increase and ensure product durability.	High	High	Sensitive analysis on lifespan shows that impacts can be reduced significantly by extending the lifespan of a furniture product. In the case of a desk[112] with an assumed lifetime of eight years of use, as defined in the functional unit. If the desk were redesigned (through a variety of design strategies) to last for ten years instead of eight years, the relative impacts of the desk would be reduced by (10 years – 8 years) / 10 years, or 20%.
		Harmonize the lifetime of the individual components.	High	High	
		Design the product so that the wear is, focus on replaceable parts.	High	High	

		Designing modular products.	High	High	
		Use as few references in the manufacture of furniture.	High	High	
		Provide replacement parts to the user.	High	High	
		Apply environmental information providers.	High	High	
		Use a suitable timber to use.(Wood)	High	High	
		To ensure the durability of the textiles and leather parts. (Textiles / Leather)	High	High	
		Designing textile covers are removable and washable. (Textiles)	Low	High	Sensitive analysis on cleaning operations for upholstered furniture (changing frequency), only modified 0.5% the overall impact of all indicators.[94]
	STRATEGY: Optimize the function	Optimize product functionality.	HIgh	High	
		Offer different wheels of different materials to choose for different soil types.	Medium	Medium	
		Offer renting and leasing services to replace the sale.	Medium	Medium	
		Adequately protect the product during transport to prevent damage.	Medium	High	
END OF LIFE	STRATEGY : Optimize the end-of-life system	Minimize the number of materials and components.	High	Medium	
		Compatible materials for use in the recycled material consisting of several parts.	High	Medium	
		Provide information on the assembly and disassembly of the product.	HIgh	High	
		Provide the user with information about the materials used in the product.	HIgh	High	
		Inform users of the potential end product life	HIgh	High	
		Marking plastic parts with an identification code. (Plastics)	HIgh	High	
		Clear coatings on metallic surfaces. (Metals)	Medium	High	
		Using recycled glass (avoid using wired glass and laminated glass). (Glass)	HIgh	High	

Sensitive analysis on different ecodesign measures applied together in furniture case studies

A sensitivity analysis is also included in this ecodesign guide[131] that assesses the jointly introduction of different ecodesign criteria for some case studies.

Product: Melanine desk. Source: Ihobe, 2010

Ecodesign measure	**Practical improvement**	**Environmental impact variation** (Ecoindicator 99, single score)
Reduction of thickness of panels	Reduction of weight	Production: -29% Distribution: -59% Use: 0% End-of-life: -19% TOTAL: -38,23%
Change from wood legs to plastic legs	Reduction of weigth Procurement from local supplier	
Packaging from manual to automatic process	Optimisation of packaging Reduction of weight	

Product: Siento chair. Source: Ihobe, 2010

Ecodesign measure	**Practical improvement**	**Environmental impact variation** (Ecoindicator 99, single score)
Redesign of back (tubular)	Reduction of weight Optimization of distribution (size)	Production: -2% Distribution: -41% Use: 0% End-of-life: -7% TOTAL: -5%
Reduction of glues	Reduction of weight Reduction of glues	
Reduction of packaging box	Optimisation of packaging Reduction of weight	

Different *eco*-design options were assessed in the study of a children furniture set[97]. Different strategies were evaluated though Design for Environment (DfE) methodology, selecting those with higher viability to be implemented and their potential of improvement (optimization of materials used, re-use of internal wastes, minimization of energy use, use of renewable energy, limited amount of packaging materials, promotion of fuels with lower impact and priorization of Euro V vehicles in transport). These measures assess applied jointly allowed global reduction of short-medium period environmental impacts of 14% of reduction).

4.3.6. Conclusions of selected LCA and EPDs

13 LCA studies were selected for this revision based on a set of quality requirements. These are considered to provide useful insight for the technical and environmental analysis of furniture products and the related revision of EU Ecolabel and GPP criteria. Moreover, 35 verified EPDs from international EPD schemes are available for furniture products (25 for office chairs , 5 for wooden panels/boards, 4 for domestic chairs and 1 for tables). Apart from these documents, other studies are also useful to handle some issues of relevance for the revision process (e.g. hazardous substances).

LCA studies cover a broad group of product broad enough to assess the revision process of EU Ecolabel. Different types of furniture are analysed: wooden panels, office and school furniture and domestic furniture.

The selected studies provide useful outcomes regarding:

- -Key environmental impacts of different furniture product systems
- -Relative contribution of different life stages to the impacts (materials, manufacturing, packaging, distribution, use and end-of-use) and main sources of concern.

-Improvement potential options (design, raw materials, production processes, distribution, life duration and end of life scenarios).

All of these elements can be used to address the revision process.

The main outcomes from the LCA review and the analysis of ecodesign measures can be summarised as it follows:

- Materials. Materials and processing of materials have the greatest impacts in most impact categories. Impacts for metals and plastics are generally higher than for wood but durability is an important issue to take into account. A lot of energy is embedded in virgin metals. Burdens can be decreased by improving resource efficiency and by recycling. Wooden materials also demand energy in their production processes, for instance for sawing and drying. Transport of materials is less important than processing, but it could become more relevant when non-local materials are used. Improvement potential options have been found at material level like the incorporation of recycled materials or the minimization of hazardous substances.

- Manufacturing. Manufacturing seems to be the second most relevant stage of the lifecycle. Energy consumption is the most important parameter, especially in processes where heating is used, such as drying in painting and coating. The use of adhesive and coating substances can also be an important source of concern in some impact categories.

- Packaging. Packaging is assessed in terms of materials used and impacts related. In general its environmental load is low but not negligible. Improvement potential options have been found.

- Distribution. Distribution is not deeply investigated since normally only average scenarios are used. However, this seems to be an issue of secondary importance only for some impact categories (e.g. ODP and GWP). Improvement potential options have been found like using local suppliers, or improvement the efficiency of vehicles.

- Use. When maintenance is included in the assessment it results to have negligible impacts. Durability is instead a key issue to minimize the impacts of furniture products.

- End-of-Life. End-of-life impacts vary depending of the waste treatment scenarios. Burdens due to landfilling are relatively low compared to the other lifecycle stages. However, significant improvement potential can be achieved by reusing and recycling products or parts of them or by recovering the energy content of waste

5. TECHNICAL ANALYSIS

In this section a preliminary technical analysis is developed following the different life stages of the system products. A specific section has been developed for the assessment of hazardous substances, which includes the substances used in processing of raw materials, manufacturing and packaging.

5.1. Raw materials

The LCA screening shows that the lifecycle environmental impacts of furniture are mainly due to the materials (on average 80-90% of the total impacts). Moreover, the kind of materials used is highly relevant since materials will condition the environmental behaviour of a product during the different life stages such as: manufacturing process, product design and lifespan, and end-of-life.

The most common materials used in the production of furniture are:

-**Wood**: Solid wood and wood based products such as panels are widely used in furniture sector. Tables, desks and cupboards are the typical products where wood panels are used. The three main categories of wooden panels are:

- ✓**Particleboard**: Wooden panels produced under heat and pressure with the addition of an adhesive to particles.
- ✓**Fiberboard:** Wooden panels produced under heat and pressure with the addition of an adhesive to glue fibres. Types of fibreboard, in order of increasing density, include particle board, medium-density fibreboard and hardboard. Fiberboard, particularly medium-density fibreboard (MDF) is heavily used in the furniture industry.
- ✓**Plywood:** Wooden panels produced under heat and pressure with the addition of an adhesive to sheets of wood.

-**Metal:** Is a base material used for example in cupboards, tables and chair legs. If the furniture is constructed and maintained properly, it may last for several years. Nowadays chairs and tables made up of metal are used extensively for exterior usage due to it can withstand strong sunlight, wind, snow, rain and hail. The main types of metals used in furniture industry are:

- ✓**Aluminium**: It does not rust, is tough, light and durable. This material is used extensively for stamped and cast furniture, especially in molded chairs.
- ✓**Steel**: Stainless steel is used widely for modern interior furnishings. It is especially suited for chair legs, supports and body pieces due to its high tensile strength, allowing it to be applied using hollow tubes and reducing weight.
- ✓**Iron**: the properties that offer cast iron (hardness, heaviness and general tough composition) are adequate for **outdoor use**, and this material is common used for bench legs and solid iron tables. The furniture made up of pure iron corrodes when it is exposed to air.
- ✓ **Other metals** are also used in fittings, like **zinc, nickel, chrome, brass, bronze, magnesium** or **lead.**

-**Plastic:** Initially, they are comparatively less environment friendly as compare to wood or steel due to they are made of harmful constituents but they are used extensively because of their light weight structure and high strength. Also they are very cheap as compare to any other material and giving the appropriate colour or shape, the plastic furniture can make it look like wood or steel furniture. A strength is that plastic can be recycled. The most common type of polymers used in furniture sector are:

✓**Thermoplastics polymers:** When they are subjected to heat, thermoplastics can be soften and bend. Then they become brittle and shatter when cooled down. Corrosion occurs due to its delicate structure. The common types of thermoplastics used in tables and **plastic lawn furniture** are:

- **Polystyrene (PS)**
- **Polyvinyl chloride (PVC)**
- **Polyethylene terephthalate (PET)**: PET is made out of ethylene and paraxylene. Their derivates (ethylene glycol and terephthalic acid) are made to react at high temperature and high pressure to obtain amorphous PET. Afterwards, the resin is crystallized and polymerized to increase its molecular weight and its viscosity. The major impact of PET is the high energy demand, much higher than PP or PE, however, PET mechanical recycling rates are high compared to other plastics[132].
- **Polyolefins:** Polyolefins such as Polyethylene (PE) and Polypropylene (PP) are simpler polymer structures that do not need plasticizers, although they do use additives such as UV and heat stabilizers, antioxidants and in some applications flame retardants. The polyolefins pose fewer risks and have the highest potential for mechanical recycling. Both PE and PP are versatile and cheap:
  - **Polypropylene (PP)** which can withstand movement, and for this reason is an appropriate material for hinges.
  - **Polyethylene (PE)**: High density polyethylene (HDPE) and low density polyethylene (LDPE).
- **Poly(methyl methacrylate) (PMMA)**
- **Polycarbonate (PC)**: Special attention should be given to polycarbonates due to the possible presence of bisphenol A. According to table 3.1 of Annex VI of CLP Regulation, bisphenol A (4,4'-isopropylidenediphenol EC 201-245-8, CAS 80-05-7) is classified as: **Repr.2**, STOT SE 3, Eye Dam.1 Skin Sens. 1 (**H361f**, H335, H318, H317)
- **Acrylonitrile butadiene styrene (ABS)**

o**Thermosetting polymers:** Thermosetting polymers provide stronger structure for furniture components, being more durable than thermoplastics. They are used as **padding materials**.

- **Polyurethane foams (PUR)** are generally used in upholstered furniture as a filling material for sofas, seats, back of seats, arm rests, etc.
- **Phenol-formaldehyde resins** are used as a furniture adhesive.
- **Urea-formaldehyde foams** used in plywood, particleboard and medium-density fibreboard.
- **Melamine resins**
- **Epoxy resins** used as the matrix component in many fiber reinforced plastics and graphite-reinforced plastics.

-**Textiles:** The most common type of textiles used in furniture sector are:

o**Cotton**

o**Polyester**

- Leather
- Polyamide

-**Padding materials:** According to the Swedish furniture industry, the average Swedish furniture products consist of 15% w/w padding materials. They are used in upholstered furniture as filling materials for seats, backs of chairs, sofas and arm rests. Padding materials are mainly:

- **Polyurethane foams (PUR-foams)**
- **Latex foams**

CFC, HFC and HCFC shall not be used as blowing or auxiliary blowing agents in the production of PUR. Padding materials shall meet the European Ecolabel for bed mattresses providing compliance with the criteria.

In the case of textiles and padding materials in the furniture, they shall meet the European Ecolabel for textiles and bed mattresses respectively, providing compliance with the criteria.

-**Other materials** used in furniture industry include glass, stone, cane, bamboo, rattan, etc. Special attention should be given to **glass** material due to the possible presence of hazardous substances such as metals like cupper or lead especially in treated glasses or mirrors such as mirrored glass where a metal coating made of silver, aluminium, gold or chrome is applied to one side of the glass.

5.1.1. Wood and wood-based products

Wood materials used in furniture can be either solid wood or wood-based materials such as panels.

Regarding the types of wood, hardwood is usually used for outdoor furniture whereas softwood, both as solid wood and wood panels, is mainly used for indoor furniture. Woods used in outdoor applications are usually durable and naturally more resistant to rain, sunlight, rot and insect infestation. Some woods, such as redwood, cypress, and the cedars, contain chemical compounds that naturally repeal bugs, bacteria, and other agents of decomposition. Others woods such as white oak and black locust have natural physical barriers as rot resistance and moisture prevention. Examples of species used in outdoor furniture are: Red Cedars, Teak, Eucalyptus, White Oak and Acacia (Locust).

The key environmental aspects of solid wood[92] are mainly related to the legal and sustainable character of the originating forest management. The impacts related to uncontrolled wood logging are for example loss of biodiversity, erosion and soil degradation.

As the majority of wood used in furniture is treated, attention must be paid also to the surface treatment of wood, especially for outdoor use. The environmental and health impacts of wooden products are linked mainly to the substances used such as glues and finishings. These substances usually contain formaldehyde resins, melamine, epoxy, polyurethane resins, ethylene vinyl acetate, etc., and will be discussed later in detail.

Energy used to transform wood materials, especially for boards, contributes significantly to environmental impacts like global warming potential and photochemical oxidant formation.

5.1.1.1. Geographic origin of timber[133]

The total wood supply to the EU accounted for 230 million m^3 in 2011. The supply comprised 176 million m^3 of domestically harvested saw and veneer logs and 53 million m^3 of imported timber

In 2011, timber importation by EU-25 represented the 17% by value of worldwide import trade. Wood product imports comprised 35% softwood, 25% temperate hardwood, 13% tropical hardwood, and 27% unknown species types (further processed products, particularly furniture from

China). Around 18% of all EU wood products imports were derived from China in 2011, mostly comprising wood furniture and plywood. Around 35% of imports are from Russia and Commonwealth of Independent States (CIS) or post-soviet States. The rest are coming from South and North America, Africa and other countries from Asia.

Technical innovation has increased the range of applications for European wood. This includes heat treatment, allowing increased use of European species for external applications formerly dominated by tropical wood. There have also been new staining and finishing techniques to alter the look and feel of European hardwoods, particularly oak. Nevertheless, EU imports remain an important component of overall wood supply, particularly in wood species and products where there is insufficient domestic availability. These include temperate and tropical hardwoods, durable softwoods, like North American western red cedar and Russian larch, and plywood, where EU production is limited. And volumes of semi-finished and finished wood product imports from lower production cost regions are actually increasing, notably furniture.

Figure 33 shows the total supply of solid timber in Europe, where 77% is European production and 23% are imports. From wood produced in Europe, around 88% of logs extracted are softwood and 12% hardwood. Most saw and veneer logs extracted in the EU are converted into sawn wood. While nearly all softwood logs are converted into sawn lumber, a higher share of hardwood goes into veneer and plywood.

Apart from 'solid timber products'; i.e. products derived from saw logs and veneer logs, it is also important to mention the large volume of wood panels, like MDF, OSB and other particleboard, made in Europe from smaller logs and waste.

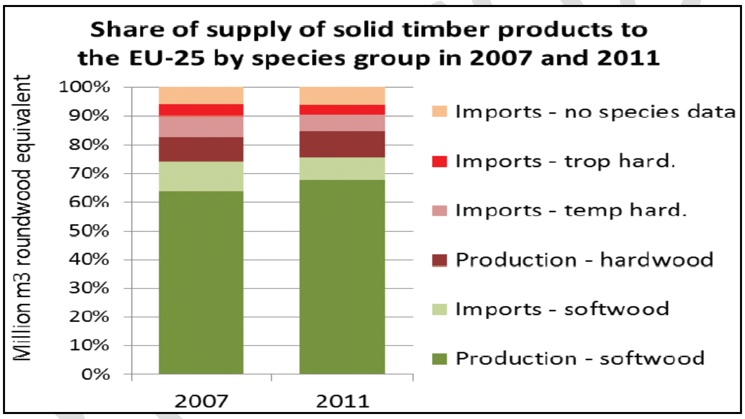


Figure 33. Supply of solid timber in EU-25 (imports and production)

Source: 2011 Statistics - EU Totals Timber trade monitoring in support of effective, efficient and equitableoperationof the EU Timber Regulation (EUTR)[133]

5.1.1.2. Use of wood from protected species

The use of tropical timber is widespread in the furniture sector. However, in many occasions these species are threatened, or are part of the habitat of endangered species. Although no reliable statistics are available, a 2012 joint study by the United Nations Environment Programme and Interpol states that illegal logging accounts for up to 30% of the global logging trade and contributes to more than 50% of tropical deforestation in Central Africa, the Amazon Basin and South East Asia[134].

In 2003 the EU initiated an action plan to counter unlawful felling known as the FLEGT action plan (Forest Law Enforcement, Governance and Trade). In March 2013,the application of the Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010 started. This regulation lays down the obligations of operators who place timber and timber products on the market. It covers a wide range of timber products, including plywood, veneer, particle board and furniture. This new regulation set three main obligations for wood traders:

- It prohibits the placing of illegally harvested timber and products derived from such timber on the EU market, whether they are of domestic or imported origin.
- Timber accompanied by a FLEGT (Forest Law Enforcement, Governance and Trade) or CITES (Convention on International Trade in Endangered Species) license will be accepted as legal. In all other cases, operators must exercise 'due diligence' when they sell imported and domestic timber or timber products.
- Traders (those after the operators in the supply chain) need to keep records of their suppliers (and customers). In this way the operators can always be traced.

5.1.1.3. Use of certified wood

Wood can be produced in plantations or extracted from natural forests. Wood obtained from sustainably managed forests does not have significant negative environmental effects. Unsustainable timber practices, such as uncontrolled logging, can involve serious disorders in the natural balance of the forest, e.g. deforestation, biodiversity loss, soil erosion and land degradation.

The main certification schemes related to sustainable forestry are listed in Table 30.

Table 30. Sustainable management forestry systems.

SCHEME	Main data
FSC - Forest Stewardship Council	Total certified area (2013): 180,552 millions ha (43.05% in Europe) No. countries: 79 Total no. certificates: 1211
PEFC - Programme for the Endorsement of Forest Certification Schemes	Total certified area (2012): 247 millions ha (35% in Europe) No. countries: 37 No. Certificates: 9.520 certificats of supply chain custody PEFC.
CSA - Canada's National Sustainable Forest Management	Canada. endorsed by the Programme for the Endorsement of Forest Certification (PEFC)
FSI - Sustainable Forestry Initiative	USA and Canada. Endorsed by the Programme for the Endorsement of Forest Certification (PEFC).

Regarding the type of wood certified, in Europe the availability of softwood from certified forestry is generally high, whereas the availability of hardwood is significantly lower. Regarding the kind of forest, 64% of forest area certified by FSC was natural forest (11.583 million ha), 28% is semi-natural and mixed plantation & natural forest (50.91 million ha), and 7.61% is plantation (13.74 million ha)[135].

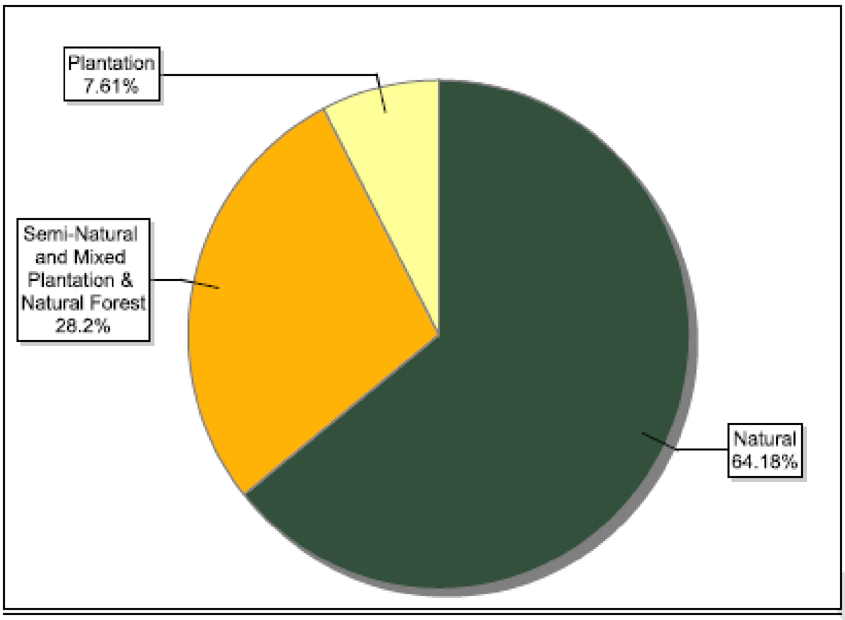


Figure 34. Types of forest certified by FSC. (source: FSC facts and figures July 2013).[135]

5.1.1.4. Recycled wood

The use of recycled wood is widely spread nowadays in the furniture industry. Many types of chipboard contain recycled fibres. This brings several environmental benefits such as the reduction of raw materials consumption and the related minimization of waste streams coming from forestry, timber production or wood products waste.

Comparisons[136] between panel boards made of virgin fibres and recycled fibres coming from panels and furniture waste, showed that there is a reduction in many environmental impacts with increase in recycled fibre content in panels. Compared to virgin panels production, the content of recycled fibres in boards shows a reduction in most impacts categories such as global warming potential, eutrophication and ecotoxicity. When the recycled content is increased, these reductions are higher. There is a potential reduction of 0.52 tons of CO_2 eq. per ton of panel produced with recycled fibers.

However, a problem associated with the use of recycled fibres is the risk of contamination, so it is necessary to ensure the quality of the boards obtained. Some contaminants that could be found in recycled wood are: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), fluorine (F), chlorine (Cl), pentachlorophenol (PCP) or creosote (benzo(a)pyrene). The presence of contaminants in recycled wood should be tested according to the European Panels Federation (EPF) Standard For delivery conditions of recycled wood[137]. This Standard fixes maximum threshold of these substances.

Elements and compounds	Limit values (mg/kg recycled wood-based material)
Arsenic (As)	25
Cadmium (Cd)	50
Chromium (Cr)	25
Copper (Cu)	40
Lead (Pb)	90
Mercury (Hg)	25
Fluorine (F)	100
Chlorine (Cl)	1000
Pentachlorophenol (PCP)	5
Creosote (Benzo(a)pyrene)	0,5

Pentachlorophenol, once widely used as a fungicide, was banned in 1987 for this use. Impregnation oils from coal tar (known as tar oils or creosotes) were the first wood preservatives to gain industrial importance. Creosote consists of polycyclic aromatic hydrocarbons (PAH´s) which some of these substances, especially benzo(a)pyrene was classified as carcinogenic. Therefore, legislative authorities have issued restrictions for the use of creosote. Tar oils containing more than 50 mg/Kg benzo(a)pyrene were banned in Europe. Moreover, according to the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012) , only biocidal products containing biocidal active substances approved by European Commission and authorised by product type shall be used for wood.

The use of recycled wood in the manufacture of particleboards or fibreboards requires deliveries of the material to the processor to ensure that reclaimed raw materials and the finished panel product are strictly controlled in respect of contaminating chemical elements and compounds that might be present at unacceptable levels in recycled wood.

A number of national quality control schemes exist. The most prominent in Europa is the German criteria defined for purposes of the RAL- Gütezeichen label "Recyclingprodukte aus Gebrauchtholz". In the United Kingdom the wood-based panels sector supports the European Panel Federation´s (EPF) "Industry Standard for delivery conditions of recycled wood", which is based on a responsible care approach. The EPF limit values reflect what is considered to be the most appropriate safety level adopted in any sector, namely those laid down in the European standard EN 71-3:1994 "Safety of Toys".

Technological developments in the toys market and the scientific knowledge have raised issues regarding the safety of toys. Increased concerns from consumers lead to a revision of the EN 71-3:1994. The new EN 71-3:2013 supports the new chemical requirements of the EU Toys Safety Directive (2009/48/EC), which take effect from 20 July 2013.

A comparsion of the migration limit of the controlled elements in EN 71-3:2013, EN 71-3:1994 and current limits according standard for delivery conditions of recycled wood are presented in Table 31.

Table 31. Comparison of the migration limit of the controlled elements in EN 71-3:2013, EN 71-3:1994 and current limits according standard for delivery conditions of recycled wood

Element	EN 71-3:2013			EN 71-3:1994		Current limits according Standard for delivery conditions of recycled wood
	Category I (mg/kg)	Category II (mg/kg)	Category III (mg/kg)	Any toy material except for modelling clay (mg/kg)	Modelling clay (mg/kg)	
Aluminum	5625	1406	70000	-	-	-
Antimony	45	11.3	560	60	60	-
Arsenic	3.8	0.9	47	25	25	25
Barium	1500	375	18750	1000	250	-
Boron	1200	300	15000	-	-	-
Cadmium	1.3	0.3	17	75	50	50
Chromium	-	-	-	60	25	25
Chromium (III)	37.5	9.4	460	-	-	-
Chromium (VI)	0.02	0.005	0.2	-	-	-
Cobalt	10.5	2.6	130	-	-	-
Copper	622.5	156	7700	-	-	40
Lead	13.5	3.4	160	90	90	90
Manganese	1200	300	15000	-	-	-
Mercury	7.5	1.9	94	60	25	25
Nickel	75	18.8	930	-	-	-
Selenium	37.5	9.4	460	500	500	-
Strontium	4500	1125	56000	-	-	-
Tin	15000	3750	180000	-	-	-
Organic tin	0.9	0.2	12	-	-	-
Zinc	3750	938	46000	-	-	-

5.1.1.5. Wood panels

Wooden panels are widely used in many types of indoor furniture, such as cupboards, tables and desks. Particleboard, fibreboard and plywood are the three main categories of wooden panels. They are produced under heat and pressure with the addition of an adhesive to glue particles, fibres or sheets of wood. The main panels in Europe are particleboard and Medium Density Fibreboard (MDF) which account for 65% and 20% of the total panel production, respectively. In 19 countries of the European Free Trade Association (EFTA), an MDF consumption of 8.7 million cubic metres was reported in 2003, as well as 2.3 million cubic metres for other European regions (22 countries)[138]. MDF is mainly used in the furniture and the building sector.

- Fibreboard is made of cellulose fibres by dry, dry / wet or humid processes through the application of heat and pressure, along with the addition of an adhesive material. Commodities may come for example from forest residues or sawmill. Medium Density Fibreboard (MDF) boards are an example of fibreboard.
- Particleboard is manufactured by applying heat and pressure to wood particles together with an adhesive. The wood particles used for particle board can be chipped, chips, sawdust or similar. Oriented Strand Board (OSB) are an example of particleboard.
- Plywood or laminates boards consist of several layers of wood glued together under pressure to give the shape. The sheets can be of different types of wood. The most used at European level are beech, birch and poplar.

Figure 35. Scheme of types of wood-based panels[138]

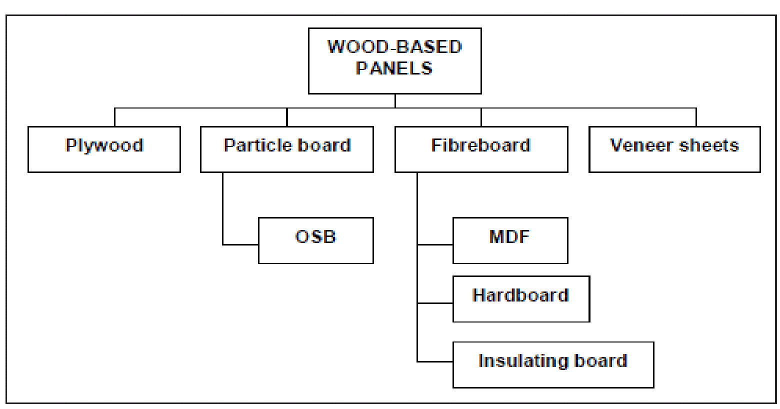


Fig. 1: Breakdown of major wood-based panels. OSB: Oriented Strand Board; MDF: Medium Density Fibreboard

Regarding board panels, different EPDs detailed the composition of different types of boards (laminates, chipboards and fibreboards) as can be seen in Table 32.

Table 32. Materials present in the different panel boards studied (LCA reports and EPDs)

Source ref.	EPD reference	Main materials (weight %)
EPDs Laminates and boards	EGGER Laminates Flex, MED, Micro	Paper ratio 57 % Resin ratio 42 % (Melamine-formaldehyde resin and Phenolic-formaldehyde resins) Additive ratio 1 %
	EGGER EUROSPAN® Raw Chipboard EURODEKOR® Melamine faced Chipboard	Wood chips, primarily spruce and pine wood, approx. 84-86 % Water approx. 4-7 % UF-glue (urea resin) approx. 8-10 % Paraffin wax emulsion <1 % Decorative paper with a grammage of 60-120 g/m² Melamine formaldehyde resin
	EGGER	Surface layers:

	EUROLIGHT® Raw and Laminated Lightweight Board	Wood chips, primarily spruce and pine wood, approx. 84-86 % Water approx. 4-7 % UF-glue (urea resin) approx. 8-10 % Paraffin wax emulsion <1 % Decorative paper with a grammage of 60-120 g/m² Melamine formaldehyde resin <u>Intermediate layers:</u> Hexagonal honeycomb out of recycled cardboard with a cell width of 15 mm Corrugated cardboard honeycomb out of recycled cardboard <u>Glueing of intermediate and surface layers:</u> PUR bonding system
	Glunz AG TOPAN® MDF AGEPAN® Wood Fibreboards	Wood chips, primarily pine, approx. 80% Water (moisture) approx. 5% to 9% (depending on air-conditioning) UF adhesive (urea formaldehyde resin) approx. 11% Paraffin wax emulsion 0.5% to 3% The coating on coated boards comprises: Decorative paper with a grammage of 60-120 g/m² Melamine formaldehyde resin
	Decorative High-Pressure Laminates International Committee of the Decorative Laminates Industry (ICDLI)	Decor paper app. 2-12% Kraft paper app. 55-62% Melamine resin app. 2-12% Phenolic resin app. 20-32%

For MDF, it was found that the fibre production and preparation stage has the highest environmental impact (more than 55%) due to energy use and chemical additive production. Subsystem of wood preparation has the largest impacts related to human health resources, as this subsystem is the most dependent on the use of electricity. Damage to Ecosystems is mainly caused by synthetic resins such as the urea-formaldehyde (UF). Other production processes such as board forming and board finishing have lower contributions.

Regarding the transport of sourcing materials (or waste in the case of recycled fibres), local materials were shown to have the lowest environmental impacts, but differences are not significant[99].

Regarding end of life, since board panels are usually used as composite materials, recycling or reuse is not possible as a rule. Panels usually have a high heating value (17-18 MJ/kg aprox.), so the generation of process energy and electricity (cogeneration plants) is possible. Comparisons among different waste treatments shows that disposal by landfill has the highest environmental impact. On-site energy from waste has the lowest impact of the disposal routes. Experimental recycling has lower impacts if avoided impacts from virgin fibres are considered[99].

From the selected LCA studies, the average contribution to the different impact categories is as follows:

- The greenhouse warming potential is the impact category more significant for wooden panels. Most of the climate change impacts are associated with the production stage, since raw materials (wood/paper) are carbon neutral materials with respect to the feedstock.
- Raw materials (approximately 25 – 85%) and production (20 – 75%) are the main contributors for the ozone depletion potential.
- Raw materials (about 30 – 80%), production (about 15 – 55%), transportation (about 8 – 20%) and EoL (about 20%) are the main contributors for the acidification potential.
- Raw materials (40-90%), production (9-50%), transportation (6%) and EoL (around 20%) are the main contributors to the eutrophication potential.
- Raw materials contributes approximately 25-80%, production (15-70%) and transportation (5%) to the photochemical oxidant creation potential.

Content of recycled fibres

Reducing the total demand of virgin fibres by using recycled fibres reduces environmental impacts. However it should be taken into account that normally much of the internal panel industry waste is used to provide process heat, allowing the reduction or avoidance of fuel combustion.

Use of resins

Usually synthetic resins are used in the manufacturing of these boards. Several consequences are associated to this type of adhesives:

- Use of non-renewable raw materials (variation in the availability and cost)
- Formaldehyde emissions
- Limited recyclability of the final product.

The most used resins are:

- Melamine-formaldehyde resin: aminoplastic resins used for the impregnation of decorative papers and overlay papers for hard, transparent lamination.
- Phenolic-formaldehyde resins: phenoplastic resins for the impregnation of the core layers; brown and relatively elastic phenolic-formaldehyde resins are used here.
- Urea-formaldeyde resins: the aminoplastic adhesive hardens fully during the pressing process through polycondensation.
- MDI (4,4' Methylene bisphenyl isocyanate) and PMDI adhesive (polymer 4.4' diphenyl methane diisocyanate)

Alternatives to petroleum based wood adhesives exist and efforts are being devoted to develop adhesives by using renewable-based substitutes based on lignin, tannin or starch[196] .

The effect of substituting non-renewable resins or reducing the amount of resins in panelboards, have been dealt within some LCA studies[114] showing environmental benefits. However, some studies indicate that these environmental benefits are lower than those achieved by other measures such as increasing the content of recycled fibres or reducing the energy[136] consumption.

In a cradle-to-gate study of hardboard[196] a new green hardboard using a two-component bio-adhesive, formulated with a wood-based phenolic material and a phenol-oxidizing enzyme, was compared to the one manufactured with the conventional phenol-formaldehyde resin. The results showed that the green Hardboard production process improved the environmental profile up to 18% in comparison with the conventional process using phenol-formaldehyde resin.

In the study of office furniture of Steelcase[114], a sensitivity analysis was done for a desk. The particleboard resin content in particleboard composition was varied to examine the effects of reducing the mass contribution of urea-formaldehyde resin. Results show that for 1% of urea-formaldehyde reduction, reductions of impacts categories were: 0.2% Global Warming Potential, 0.44% of energy resource consumption, 0.58% of acidification potential. Reducing the mass contribution of urea-formaldehyde resin from the current level of 9.5% to 4.9% achieved the following impacts reduction: 20% of global warming, 58% of acidification potential.

For MDF board manufacturing, reduction of the resin content was assessed (typically 11% to 12% was added during the trials to ensure good wetting of recycled fibres). It was found that there was a positive effect of reduction of the resin content to 10% by weight regarding the environmental impacts. However, this effect is not large in relation to other production impacts and may be deemed insignificant[99].

5.1.1.6. Genetically modified organisms

Genetically modified organisms (GMOs) are organisms that have been transformed by the insertion of one or more isolated genes. Scientists and the public have expressed worries with regard to the risks of potential gene flow (gene transfer to breeding populations or wild relatives, potentially leading to hybridization or introgression, sometimes referred to as genetic pollution) and environmental impacts (e.g. the displacement of local species).

In agriculture, genetically modified organisms (GMOs) are already reality: the area of genetically modified crops increased from 2.8 to 67.7 million hectares between 1996 and 2003, and genetically modified crops were being raised commercially in 18 countries in 2003. More than half the area of soybean planted globally is transgenic. The forestry sector is far behind agricultural crops in this respect[139].

A study from the Food and Agriculture Organization of the United Nations (FAO) suggested that as of 2002, less than 500 ha of genetically modified forest trees (poplar clones) were being grown commercially in China. *Populus* is the genus of forest tree in which genetic modification has been researched most widely, although some genetic modification research has been reported for about 19 genera of forest trees.

The Forest Stewardship Council (FSC), bans all forms of genetically engineered trees on certified lands.

The potential hazards of GMO trees include the following[140]:

1. Reduced diversity: plantations using one or few transgenic clones will contain less landscape-level diversity than is currently found in plantations using species or varieties resulting from traditional tree-breeding.
2. Asexual transfer of genes from GMOs with antibiotic resistance to pathogenetic micro organisms, and/or suppression of mycorrhizae and other micro-organisms, arising from use of GMOs with antibiotic resistance.
3. Spread of herbicide resistance gene in sexual progeny to trees in environments where those trees are undesirable and where the target herbicide is used, and/or increased weed resistance to target herbicide, and/or increased use of target herbicide arising from use of GMOs with herbicide resistance.
4. Increased resistance of target insect pests, and/or deleterious effects on natural enemies of the target insects, and/or deleterious effects on non-target insects such as butterflies, pollinators and soil microbes, arising from use of GMOs with insect resistance.
5. Changes to structural integrity, adaptation and pest resistance of trees, rate of decay of dead wood, and soil structure, biology or fertility, arising from use of GMOs with modified lignin chemistry.
6. Dispersal of transgenes to wild or weed populations, with potentially negative impacts, from non-sterile GMO trees, or from those with incomplete or unstable sterility.
7. Restricted or monopolistic access to advantages, arising from high costs or limited availability of GMO trees.
8. Reduced biodiversity of organisms dependent on flowers and fruits, arising from use of sterile GMOs.
9. Reduced adaptability to environmental stress, changes to interaction with other organisms, and increased weediness or invasiveness, in GMO trees with new features.

5.1.2.Non Wood Forest Products (NWFP)

The Food and Agriculture Organization of the United Nations (FAO) defines NWFPs as “products of biological origin other than wood derived from forests, other wooded land and trees outside forests (FAO 2007). The term encompasses all biological materials other than wood which are extracted from forests for human use, including edible and non-edible plant products, edible and non-edible animal products and medicinal products (e.g. honey, nuts, pharmaceutical plants, oils, resins, nuts, mushrooms, rattan, cork).” Although most NWFPs predominantly have value for local trade, some are important export commodities for international trade. Bamboo and rattan are considered the two most important NWFPs[141].

Main Non Wood Forest Products (NWFP) that can be found in furniture products are: bamboo, rattan, cane, wicker, hemp, osier, sisal, cork and reed. Nowadays the certification FSC is available for bamboo and cork.

In furniture industry, NWFP materials can be used as stemp or could also appear in new board materials and composites. Some examples of furniture industrial applications are:

- New industrial bamboo materials with different properties and possibilities, such as Bamboo Mat Board (BMB), Strand Woven Bamboo (SWB), Bamboo Particle Board, and various Bamboo Composites.
- Chipboard with addition of biomass remains from agriculture (straw or flax). Plastic composites with addition of biomass.
- Linoleum used for tabletops and cupboards (linoleum can be confused with PVC).
- Cork covering for boards.

Bamboo

Demand for bamboo products has increased significantly. At present bamboo is also available as FSC-certified material, although little bamboo from certified areas is available. Other Ecolabel Schemes such as Nordic Ecolabelling have criteria regarding bamboo to ensure that raw materials do not derive from areas where biodiversity or social conservation values are under threat.

Bamboo is a type of grass and is the fastest growing plant on earth. Because of its high growth rate and easy processing, bamboo is a promising renewable resource that could potentially substitute for slow growing hardwood. Bamboo has good mechanical properties, has low costs and is abundantly available in developing countries. Its rapid growth and extensive root network makes bamboo a good carbon fixator, erosion controller and water table preserver. The bamboo plant is an eminent means to start up reforestation, and often has a positive effect on groundwater level and soil improvement through the nutrients in the plant debris[142].

Over 1200 bamboo species grow in Asia, Central America and South America and some species grow in parts of Africa and Australia. Bamboo grows wild as a "weed" and does not normally require fertiliser or spraying. Bamboo is often cultivated by peasant farmers, but because of the increased pressure on bamboo there is a danger that the felling of forests and the use of insecticides and fertilisers will result in the destruction of well-functioning eco systems. According to INBAR (International Network for Bamboo and Rattan[143]) bamboo is viewed as a natural resource and is harvested from unregulated natural forests in South-West China. In many places however the practice followed during harvesting is such that it may harm habitats that are dependent upon bamboo (such as the Red Panda and the Giant Panda) and also destroy the eco system in general. Bamboo is also cultivated in plantations of various types.

Through industrial processing of bamboo virtually anything that can be made from wood can also be developed in industrial bamboo materials. The industrial processing of bamboo and in particular the lamination of bamboo strips into boards (Plybamboo), which is mostly applied in flooring, furniture board, and veneer, started in China in the early 1990s. China is still the leading industrial bamboo producer worldwide and supplies more than 90% of bamboo flooring and board materials in Western Europe.

As mentioned in the previous section, bamboo is often perceived as being environmentally friendly. There are many qualitative arguments, mainly around the biomass production of bamboo, that justify this positive perception. However, many of the industrially produced bamboo materials (Plybamboo, Strand Woven (SWB), etc.) go through many energy intensive production steps, produce a lot of waste and are supplemented with many chemical substances (glue, lacquer, etc.). The same applies to many wood based products.

The environmental performance of various bamboo materials were compared with alternatives in applications in the building and furniture sector in which the specific properties of bamboo can be utilized: bendability (Plybamboo, BMB), aesthetics (stem, Plybamboo, SWB) and durability outdoors (SWB) based on current use in Western Europe.

- **Stem:** In all applications where the bamboo stem may be used, European grown wood scores better in terms of environmental impacts. Due to its efficiency in form and processing, and the high growing speed, in annual yield the stem scores significantly better than even the fastest growing softwood species. However, due to the irregular form and high transport costs, the market potential of the stem for mass applications in Europe is limited which makes this high annual yield of limited use.
- **Indoor boards (e.g. Plybamboo):** In applications where Plybamboo is typically used (flooring, tabletops), it performs worse in terms of environmental impacts than locally grown hardwood and wooden board materials (MDF, plywood) based on fast growing softwood species. However, it has lower impacts than FSC certified tropical hardwood (Teak) and tropical hardwood derived from natural forests.
- **Outdoor applications (e.g. Strand Woven Bamboo (SWB):** For outdoor applications most softwoods are not eligible due to their low durability, and tropical hardwood is often used. In high end applications (e.g. decking), SWB has higher environmental impacts than suitable plantation grown tropical hardwood species such as Teak and Azobé. However, SWB scores significantly better in environmental behaviour than timber which is derived from natural tropical forests and FSC certified tropical hardwood. Therefore, if SWB can help replace tropical timber from natural forests it may be considered an environmental friendly alternative.

5.1.3. Metals

The most relevant types of metals for the production of furniture are aluminium, steel (mainly stainless steel) and iron (especially in outdoor furniture). They are used as a base material, for example in table and chair legs, and cupboards. However other types of metals may also be used in fittings such as screws and fixings.

The most significant impacts related to metal production are[92]:

- Influence on landscape by mining activities to obtain bauxite, iron ore and other minerals.
- Metal contamination in local water sources and emissions of dust and noise during mining processes.
- Materials and energy consumption, release of heavy metals (mostly through wastewater) and emission of dust and pollutant gases (e.g. fluorine, nitrogen oxide, sulphur oxide) during metal manufacturing.
- Emissions of heavy metals and other compounds when the metal undergoes surface treatment (galvanisation, painting, lacquer, enamelling) in order to extend durability and aesthetic value, except for stainless steel which does not need surface coating.
- Use of non-renewable resources,
- Although reserves are supposed to last for several hundred years.

At the end-of-life, metals are totally recyclable. In order to facilitate recycling, it is important to ensure that the metal parts of furniture can easily be removed for their selective collection for recycling.

<u>**Recycled metals**</u>

The use of secondary (recycled) metals appears as one of the most efficient measures to reduce the environmental impacts associated to metals. Nowadays the majority of metals used in the furniture sector (steel, aluminium) come from recycled sources in a certain percentage.

Increasing the share of recycled materials in metal considerably reduces the energy needed to produce steel and aluminium. For example the energy needed to produce 1kg of 100%-recycled aluminium is approximately 10% of that needed for the production of primary aluminium. Beyond energy savings this also reduces the impacts of mining and final waste streams.

The use of secondary metals (recycled metals) can lead to two major environmental benefits:

- Reduced consumption of natural resources: the use of recycled metals reduces the need for raw materials in the mining operations and reduces the use of other additional materials in the process of obtaining the required alloys.
- Reduction of waste generated: Using recycled metals will have achieved that metallic waste from various sectors have been exploited by a second merger, so that the amount of final waste to landfill will be reduced.

5.1.3.1. Aluminium

Many properties such as its lightweight, strength, recyclability, corrosion resistance, durability, ductility, formability and conductivity make aluminium a valuable material widely used in furniture products.

The total aluminium metal supply in Europe in 2011 was 13.2 million tonnes. From this aluminium, 35% was produced by European primary smelters, 30% was net-imported and 34% was recycled by European refiners and remelters[144].

Recycled aluminium production (refining and remelt) in Europe reached around 4.3 million tonnes in 2010, 2.2 millions of which produced by refiners. Worldwide, some 7.7 million tonnes were produced by aluminium refiners.

For primary aluminium, the main environmental impacts are due to non-renewable resources and energy consumption needed for transforming the raw material (bauxite) to aluminium, and the waste generated. Producing one tonne of Aluminium requires 5 tonnes of bauxite. Open cut mining of bauxite degrades $50m^2$ of land per tonne of Aluminium produced. The most notorious by-product of Aluminium production is caustic red mud and red sand.[145]

The LCA studies reviewed on aluminium furniture[104,117] showed that aluminium was the material with higher impacts in relation with its weight. These studies also confirm that the use of secondary aluminium had important environmental impact benefits. Sensitivity analysis pertaining to the recycled content of aluminium showed that use of aluminium with high recycled content was beneficial; this is because production of recycled aluminium is less energy intensive than production of primary aluminium.

Aluminium is 100% recyclable with no downgrading of its qualities. The re-melting of aluminium requires little energy: only about 5% of the energy required to produce the primary metal initially is needed in the recycling process[106]. Whereas primary aluminium has an energy demand between 170-145[104] MJ/kg, secondary aluminium requires only 8MJ/kg[146] - 15.9[104]MJ/kg. These energy savings bring important environmental savings for furniture products[104]. For office furniture[114], the contribution of secondary aluminium to the overall composition of products made from extruded aluminium was done. Per every one percent increase in recycled content, the reduction in the different impact categories was: 0.54% of reduction in Global Warming Potential, 0.56% of energy reduction, 0.62% of acidification potential.

As stated above, aluminium is a metal totally recyclable. Sensitive analysis performed in LCA studies assessing differentwaste-management scenario showed that recycling at end-of- life resulted in a significantly lower GWP100 and landfilling at end-of-life[117].

5.1.3.2. Steel

Steel furniture comprises chairs, tables, cabinets, racks, sofa sets, etc. They are required in almost all places, e.g. for domestic purposes, offices, factories, etc.

The European steel industry is competitive and well established in a majority of Member States. Steel is produced in an energy intensive process by reducing iron ore, or by melting recycled scrap. A wide variety of steel products is used in different industries like shipbuilding, automotive, construction and transport. Steel is recovered from end-of-life goods and recycled without loss of its intrinsic properties, which adds to its competitiveness and environmental benefits. With a production of around 200 million tonnes of crude steel in 2008, the EU represents 16% of the world steel output and is the second biggest producer behind China[147].

Recycling has grown in parallel with increased steel consumption. In 2007, the production of secondary steel represented 56% of the total European steel production[147]. Recycling of steel scrap has economic as well as environmental advantages for the steel industry by saving resources and energy.

The production of one ton of steel requires 1,500kg iron ore, 225kg limestone, 750kg coal (coke) and 150,000 litres of water. Each tonne of steel produced generates the following wastes: 145kg of slag, 230kg of granulated slag, 2 tonnes of CO_2 and 40kg of noxious gas (carbon monoxide, sulphurous oxides and nitrous oxides). Approximately 150,000 litres of contaminated water are also produced.[148]

The use of recycled steel has several impact savings due to the avoided consumption of non-renewable resources and energy. One ton of recycled steel results in a saving of[106]:

- 1,135 ton of iron mineral
- 0,055 ton of limestone
- 0,635 ton of carbon

From the analysis on environmental benefits of steel recycling, it was established that there are numerous advantages of scrap utilisation. The major environmental benefits of increased scrap usage comes from the fact that production of one tonne of secondary steel consumes only 9–12.5 GJ/t, whereas the primary steel consumes 28– 31 GJ/t and consequently enormous reduction in CO_2 emissions[149].

5.1.3.3. Iron

Cast iron is used mainly for outdoor finishings and settings, such as those used for bench legs and solid iron tables. It is suited for outdoor use due to its hardness, heaviness and general tough composition. Cast iron is a durable and recyclable material, which can be recycled indefinitely with no decline in properties.

5.1.4. Plastics

Approximately 50% of plastics are used for single-use disposable applications, such as packaging, agricultural films and disposable consumer items. Around 25% is used for long-term infrastructure such as pipes, cable coatings and structural materials. The remainder is used for durable consumer applications with intermediate lifespan, such as in electronic goods, furniture, vehicles, etc[150].

The main plastics used in furniture are: Polystyrene (PS), polyvinyl chloride (PVC) and polypropylene (PP). Other plastics like polycarbonate, polyamide6 (PA6)/nylon or ABS (Acrylonitrile Butadiene Styrene) are used as well.

Plastics constitute a large range of products conventionally produced from natural gas or crude oil. Some of the impacts related to plastic production are[92]:

- The use of non-renewable resources;
- The use of energy
- The use of additives such as stabilisers, plasticisers or flame retardants which can present inherent hazardous properties;

- The release of pollutant and hazardous substances during production.
- Release of pollutant and hazardous substances during handling of waste. Although plastics can also be recycled, waste can be problematic if plastic parts cannot be easily removed from the furniture and their type identified.

Many plastics used by industry contain chemical additives to provide specific characteristics to the materials such as flexibility, durability, colour, etc. Some of these additives (polybromate flame retardants, phthalates, perfluorinated compound (PFC), heavy metals) can be dangerous for the environmental and the human health *(see section6 on hazardous substances).*

Polyvinyl chloride (PVC)

PVC furniture is most commonly found outside as patio or poolside furniture. PVC furniture is considered to be sturdy and long-lasting, which is why it is commonly featured outdoors with constant contact with the sun and other elements.

Polyvinyl chloride (PVC) is a synthetic polymer material (or resin), which is built up by the repetitive addition of the monomer vinyl chloride (VCM). The chlorine in PVC represents 57% of the weight of the pure polymer resin.

PVC has been at the centre of a controversial debate during the last two decades. A number of diverging scientific, technical and economic opinions have been expressed on the question of PVC and its effects on human health and the environment. Some Member States have recommended or adopted measures related to specific aspects of the PVC life cycle. However, these measures vary widely[151]. PVC is discussed in terms of environmental impact and health and environment issues mainly due to the use of the vinyl chloride monomer (VCM) and additives such as phthalates.

From a PVC life cycle perspective[152], the production of intermediates, particularly the processes from the resource extraction of crude oil and rock salt up to the VCM production, play a major role for the environmental impacts. Most of the impacts are caused by emissions to air and water, especially by hydrocarbons, nitrogen oxide and sulphur dioxide emissions to air.

The production of stabilisers and plasticizers plays a significant role, whereas the production of pigments offers a comparatively low optimisation potential, because of the small volumes involved. The most commonly used plasticisers are phthalates, of which di-2-ethylhexyl phthalate (DEHP) has traditionally accounted for 50% of European phthalate use. Others include diisononyl phthalate (DINP), di-isodecyl phthalate (DIDP), di-butyl phthalate (DBP) and butylbenzyl phthalate (BBP). All these phthalates are classified as toxic for reproduction.

PVC is also difficult to recycle given the presence of additives including heavy metals such as lead and cadmium (though their use decreases or has been banned in some countries in the case of cadmium). In fact, PVC is considered a contaminant in other recycling streams. Currently only a small amount of PVC post consumer waste is being recycled, whereas the 82% of PVC post-consumer waste is landfilled, and 15% is incinerated. Incineration, in conjunction with municipal waste disposal, is a simple option that allows for the partial recovery of energy and substances, if state-of-the-art technology is applied. In case of uncontrolled incineration (or incineration under non-BAT conditions) concerns related to dioxin formation are raised. From an LCA point of view, PVC disadvantages within a mixed waste fraction since the usability of the waste is limited[153].

Some ecolabel schemes, e.g. the Nordic Ecolabel, restrict the use of PVC in furniture. The rationale is that PVC is not suited for combustion because the content of chlorine may contribute to increased development of dioxin in the waste gas from the waste incineration plant. PVC is often deposited and part of the hard PVC is recycled for production of new PVC. The problem is that for a general consumer often is it difficult to distinguish between materials containing PVC and the ones not containing PVC. Therefore a large part of the PVC waste ends in the rubbish which is combusted, even though PVC is defined as not suitable for combustion[154].

Polyolefins (PE and PP)

Polyolefins such as polyethylene (PE) and polypropylene (PP) are simpler polymer structures that do not need plasticizers, although they do use additives such as UV and heat stabilizers, antioxidants and in some applications flame retardants. The polyolefins pose fewer risks and have the highest potential for mechanical recycling. Both PE and PP are versatile and cheap, and can be designed to replace almost all PVC applications. PE can be made either hard, or very flexible, without the use of plasticizers. PP is easy to mould and can also be used in a wide range of applications.

In comparison with PVC, PE and PP use fewer problematic additives, have reduced leaching potential in landfills, reduced potential for dioxin formation during burning (provided that brominated/chlorinated flame retardants are not used), and reduced technical problems and costs during recycling.

5.1.4.1. Recycled plastics

The use of recycled plastics is currently feasible in the furniture sector, although some limitations can exist for some components such as colour limitations, resistance requirements to mechanical and physical stress or other technical properties. However, in general, most of the furniture components do not need virgin plastic and they could be produced from recycled plastics.

For indoor furniture, use of recycled plastic is relatively common. For office chairs, from the 29 available Environmental Product Declarations (EPDs), 15 used recycled plastic at some extent.

In the Nordic Ecolabelling criteria for outdoor furniture[154], products consisting of more than 10 weight % plastic, a minimum of 50% of the plastic must consist of recycled material. A study done by Nordic Ecolabelling about the possibilities for using recovered plastic in furniture stressed that plastic does not have unlimited durability and that there are restrictions on the number of times it can be re-used. This is because the long polymers of the plastic break down and become shorter as a result of both preparation and use of the plastic. As a result the mechanical properties and durability deteriorate. Many polymers are affected by UV light and the acid content of the atmosphere. Therefore anti-oxidants and stabilisers are added to protect the plastic and thereby extend its durability. The additives deteriorate over time. Polypropylene in particular becomes brittle and breaks into pieces when the anti-oxidants in the plastic have been consumed. In the case of some types of plastic, anti-oxidants are also added to recycled plastic. However, this has a negative effect since as a result the plastic will contain many different types of additives where, for example, the anti-oxidant and filler used will not always perform well together. This can cause quality problems. The report concludes that if recycled plastic is to be used, then it is likely that production waste will be the only type that is suitable for the production of furniture. This is because the traceability of the plastic flows is better allowing purer plastic in terms of additives and plastic types to be used. Recycled postconsumer plastic is best suited for simpler products without the same quality requirements as regards the plastic.

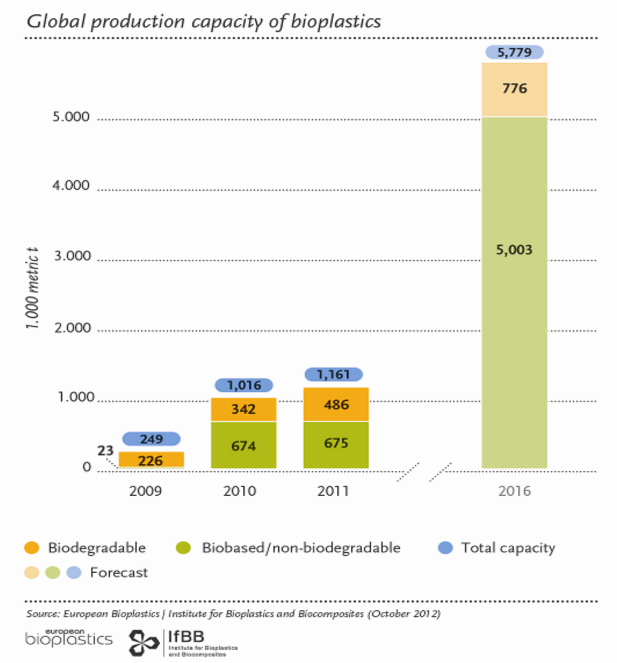
The use of recycled plastic will be more limiting for outdoor furniture since it is more exposed to sunlight and the acid in the atmosphere than furniture for indoor. Plastics for outdoor furniture will need to have a high content of anti-oxidants and stabilizers, and it will be difficult for outdoor furniture to source recycled plastic with the required of quality.

5.1.4.2. Bio-Plastics (Polymers made with renewable resources)

Nowadays 500,000 tonnes of bioplastics are produced every year. The European market for bioplastics is growing at an annual rate of roughly 20 percent. The applications for bioplastic materials and products are increasing steadily. Today, bioplastics can be found mainly within the following market segments: packaging, food-services, agriculture/horticulture, consumer electronics, automotive, consumer goods and household appliances. Other markets start to use bioplastic materials as well, such as building and construction, household, leisure or fibre applications (clothing, upholstery) and furniture (e.g. chairs, tables, shelves, cupboards).[155]

In Europe in 2010, 120 tons of biopolymers were used for the building sector and furniture. However, worldwide furniture manufacturers seem more interested to focus on the recyclability of energy intensive materials rather than on the utilization of renewably sourced biopolymers[156].

Figure 36. Evolution of the use of bioplastics in Europe



Source: European Bioplastics[157]

There are two possible categories of plastics that can be derived from renewable resources. One option is the production of new monomers (such as polylactic acid) to make new, possibly biodegradable, polymers (e.g. Polylactic acid or PLA). The commercial challenge is to compete with existing large volume plastics in terms of production economics and adapting processing equipment. The other route is to make high volume monomers such as ethylene (or other ethylene derivatives) from ethanol derived from renewable sources. This can then be used in existing polymerisation plants making the well-known polyethylene grade ranges. In both cases the chemistry is proven, but a key consideration will be the amount of non-renewable energy used in the overall manufacturing chain.

Bio-based plastics can be made out of products obtained from raw materials produced by a natural living or growing systems, such as starch and cellulose. The advantage of bio-polymers is that they readily degrade and can be composted. Natural polymers include cellulose (from wood, cotton), horn (hardened protein) and raw rubber. Converted natural polymers include vulcanized rubber, vulcanized fibre, celluloid and casein protein.

Biodegradable plastics from renewable sources (bio-based) are seen as a promising alternative for plastic products which have a short life cycle or are impractical to recycle, such as food packaging, agricultural plastics and other disposables. For polymers made of renewable sources, it is important to consider its sustainable origin and management. For lasting applications like furniture products, bioplastics have a very limitated use due to some requirements such as durability. Current developments of new types of bioplastics with improved funcitionality can expand the use of bioplastics to new sectors using semi-durable and durable products.

5.1.5. Glass

Flat glass is the material that goes into a variety of end products including applications such as furniture. Flat glass is the second largest sector in the glass industry in the European Union after container glass and it represents around 30% of total glass production worldwide. In 2008, the sector reached a production capacity of 12.7 million tonnes of float glass[158].

In most cases, transport costs make it uneconomic for flat glass to travel long distances by land. Typically, 200 km would be seen as the norm, and 600 km as the economic limit for most products, though this varies between markets. It is possible for float glass to be economically transported along longer distances by sea provided additional road transportation is not required at both ends. This tends to favour float lines with local port access unless a local market is available for the line's output. This is the reason why the vast majority of glass produced at the EU borders such as in Algeria, Egypt, Ukraine, etc. can be easily transported and sold in the European Union.

The main types of flat glass are:

- Annealed glass: is the basic flat glass product that is the first result of the float process.
- Toughened glass: is treated to be far more resistant to breakage and to break in a more predictable way when it does break, thus providing a major safety advantage in almost all of its applications. Toughened glass is made from annealed glass treated with a thermal tempering process. Toughened glass has extremely broad applications in products for buildings, automobiles and transport, as well as in other areas. Car windshields and windows, glass portions of building facades, glass sliding doors and partitions in houses and offices, glass furniture such as table tops, and many other products typically use toughened glass.
- Laminated glass: Laminated glass is made of two or more layers of glass with one or more "interlayers" of polymeric material bonded between the glass layers. Laminated glass offers many advantages. Safety and security are the best known of these, so rather than shattering on impact, laminated glass is held together by the interlayer. Laminated glass is used extensively in building and housing products and in the automotive and transport industries.
- Coated glass: Surface coatings can be applied to glass to modify its appearance and give it many of the advanced characteristics and functions available in today's flat glass products, such as low maintenance, special reflection/transmission/absorption properties, scratch resistance, corrosion resistance, etc.
- Mirrored glass: To produce mirrored glass, a metal coating is applied to one side of the glass. The coating is generally made of silver, aluminium, gold or chrome. For simple mirrored glass, a fully reflective metal coating is applied and then sealed with a protective layer.
- Patterned: Patterned glass is flat glass whose surfaces display a regular pattern. The most common method for producing patterned glass is to pass heated glass. Patterned glass is mostly used in internal decoration and internal architecture. Today, it is typically used for functional reasons, where light but not transparency is desired.
- Extra clear glass: Extra clear glass differs from other types of glass by its basic raw material composition. In particular, this glass is made with a very low iron-content in order to minimise its sun reflection properties.

The extraction of raw materials for the production of glass is not as problematic as for other components because this material is made of resources that are abundant in nature, such as sand, soda ash, limestone, with a dash of dolomite and feldspar. However, extraction is carried out in mines, with high consumption of natural resources, use and destruction of large areas of land, altered morphology and physical chemistry soil, air pollution, alteration of the water balance of groundwater, water infiltration contaminated waste, ground subsidence and imbalances in vegetation, etc.

Production of glass entails high amounts of energy, since processes are done at high temperatures. This energy consumption has relevant impact contribution to overall glass impact.

Another problematic issue can be the presence of hazardous substances such as metals like cupper or lead (especially in mirrors or treated glasses).

Regarding recyclability, processed glass like laminated glass (with a polymer layer) or mirrored glass (with a metal layer) can be difficult to recycle. Although some recycling processes exist that separate the different components, they are expensive and limited. So they are few accepted in current glass recycling systems.

Glass can be an important component in some furniture and can have relevant contribution to environmental impacts. As an example a mirrored glass in cabinet (19.3% of cabinet weight), contributes to 16.4% of global warming caused by materials and 20.8% of acidification caused by materials (mainly due to electric and thermal energy consumption).

One of the more efficient measures to reduce environmental impacts from glass material production is the use of recycled glass. The glass components of furniture can be easily made of a percentage of recycled glass with no major technical limitations below 85%. The main environmental benefits are[93]

- Energy savings (20%)
- Reduction of consumption of natural resources
- Reduction of waste generated

5.1.6. Textiles and leather

Textiles are used in upholstered furniture such as seats, backs of chairs, sofas and arm rests. Textiles can be produced from various materials, both from natural fibres such as cotton, wool, jute or flax and synthetic fibres such as polyester and polyamide. Virtually all types of textiles are applied in the furniture industry. Leather is also used, though less frequently.

Textile fibres are usually treated with various finishing agents to make them durable, hard-wearing, soft or to give them different appearances (e.g. bleaching and dyeing). Natural fibres may also be treated with a mothproofing agent. Textiles used in upholstery are easily inflammable and are often treated with a flame retardant.

Leather is generally tanned with chromium salts or plant extracts in a number of different processes. It is then oiled (e.g. with linseed oil) and dyed (typically with synthetic dyes). Surface treatment (finishing) gives the leather its final appearance and makes it dirt- and water-resistant. Various finishing substances are used that may damage the environment and health. Depending on tanning method, dyeing, and surface treatment, leather emits VOC solvents[159].

The impacts of the different fabrics used for upholstery are mainly due to the production phase.[160]. The main environmental impacts and health related issues are associated with:

- The use of pesticides (in case of natural fibres) during the cultivation phase;
- VOC (volatile organic compound) emissions to air (in the case of plastic fibres) during the production phase;
- The emission of dyes, pigments, fungicides, chromium compounds, etc. to water – during the treatment of fibres and tanning of skin fibres to produce leather;
- The presence of hazardous substances in the product, such as formaldehyde, heavy metals and azo dyes.

For upholstered furniture[94], sensitive analysis was done for the nature of textile and site of fabrication of textile/cover, It showed that air acidification is a sensitive indicator of transport of textile, but have low variation in general due to the low weight of cover regarding all furniture. Regarding the type of textile, linen has minor impacts than cotton (due to a lower water consumption and chemicals) and polyester (with lower impacts than cotton, but higher impacts than linen due to the use of fuel-oil).

According to statistics of the International Council of tanners[161], in 2007 the furniture sector used 3210 million square feet of leather in the world (14% of total leather production). Environmental impacts from leather can be related to the different life stages of the material:[162]Agriculture, cattle breeding and slaughtering; processing of leather (tanning process), plastics and other synthetic materials, manufacturing of finished products (usually less relevant). Main hot spots identified in different studies are: slaughtering, tanning chemicals (where usually chromium salts and other heavy metals are used) and consequent tannery solid wastes and wastewater.

5.1.7. Padding materials

The main foaming materials used in upholstered furniture are polyurethane foams (PUR), polyester or polyether, and latex foams. They are used as filling material for seats, backs of chairs, sofas and arm rests.

The most important aspects, which can be tackled in setting criteria for padding materials, are:

- Use of hazardous substances in the production process (see section 6.3.)
- Presence of hazardous residues in the foams
- Durability of the final product
- Use of raw materials

5.2. Manufacturing

The processing of components is usually considered as part of the materials stage in LCA studies. The components are:

- Wood components: wood process starts with logging activities and further processing include sawing, protective treatment and drying of wood. Transport of timber is usually included in wood components processing;
- Wooden panels: wooden panels are made of virgin or recycled sawn wood or fibres, which are processed under heat and pressure with the addition of adhesives and resins;
- Metal parts: metal materials are transformed through different forms (sheets, cast pieces or extrusion profiles) depending on the final product;
- Plastic parts: polymers are processed through different processes depending on the final component (injection, calendering, film blowing, etc.);
- Glass: flat glass components are made by float process. Depending on the type of glass, different thermal or coating process are applied to give the glass specific properties.

Usually furniture manufacturers receive elaborated or semi-elaborated components from suppliers. Once the components are manufactured, assembly and finishing are the main actual production steps for a final furniture item. This stage implies the assembly of the different components and/or furniture parts in order to produce the final product. Manufacturing processes vary depending on the kind of furniture and materials used.

Apart from assembly, other manufacturing process can be done, depending on the type of furniture:

- cutting of wooden panels, metal sheets or plastic pieces;
- edging;
- drilling;
- assembly (used of adhesives);

- surface treatment of the final furniture;
- packaging of furniture (used of packaging and adhesives).

The manufacturing stage has lower impacts than the materials stage (which include raw materials extraction, material processing and transport of these materials). On average, it was found that manufacturing stage has a contribution of 10% in the overall environmental impact of a furniture product. For the manufacturing, the main contributions in all impact categories are due to energy consumption (electricity and heating).

Manufacturing stages with higher contribution are those including treatment of materials such as surface coating, glueing, etc. with the use of chemicals and energy consumption. Coating processes (such as UV coating, PUR, application of insulation rolls or paints) can lead to significant electricity and fuel consumption (70% of total manufacturing energy demand) mainly due to drying process in furnaces.

Nevertheless, energy consumption in manufacturing process is lower than energy embodied of materials.In the studies done by Unione Industriali Pordenone[100,101,102,103,104] some energy patterns from manufacturing process is detailed:

- Electricity: used for facilities (30% aprox.) and productive processes such as cutting, edging, coating, finishing (70% aprox.).
- Thermal energy: used for heating facilities (50% aprox.) and productive processes (furnace for coating processes).

Table 33. Energy consumption in manufacturing processes (core processes)

	Energy consumption(MJ)	% of energy consumption in manufacturing process (respecting total energy demand of product)	Observations
Cabinet (Mascagni)	153.9 MJ /10kg	26.7%	
kitchen	131.5 MJ/10kg	32.9%	
Desk (Martex)	17.2/10kg	2.1%	No painting
Cabinet (Martex)	79.2/10kg	14.9%	
Workplace	69.3/10kg	10.3%	
EPDs on office chairs (average)	74 MJ /Seat	7%	

In section 6, the different manufacturing processes and the use of different substances are assessed in detail, including preservatives, flame retardants and surface coatings (both for components and finished furniture) as well as glues and adhesives used during assembly of furniture.

5.3. Packaging

The main function of packaging is to protect the product. Due to the bulky, heavy and delicate nature of furniture, it is easy to damage during transit. Therefore a protective packaging is required. Normally two types of packaging are required: transportation or secondary packaging (such as pallets) and primary package (to be transported from shop to final user site).

In some cases, especially with small furniture, the weight of the packaging can contribute significantly to the total weight of the packed furniture. From the LCA screening, the average contribution of packaging in weight is as follows:

- 13% of the total product weight for office chairs
- 9% of the total product weight for domestic chairs
- 7% of the total product weight for office desks

- 8.5% of the total product weight for cabinets/wardrobes
- 44% of the total product weight for tables.

The material used for packaging is usually corrugated cardboard, but packaging can also contain plastics (e.g. PS and PP), paper or metal pieces (e.g. steel).

The use of single-use packaging in the furniture industry is much extended. These packages have a very short lifespan, being discarded immediately after distribution. Main environmental problems related to packaging come from the consumption of raw materials and packaging waste. Environmental impacts could be reduced by:

- the use of packaging made from recycled materials,
- recyclable packaging
- reusable packaging.

LCA studies[108] show the contribution in weight of packaging, its composition and relative contribution in some key environmental impacts.

Table 34. Composition and environmental impacts of packaging

	% on weight	Composition of packaging	Overall contribution to impacts
Cabinet 1	4.7% of weight	Cardboard (84%) Polystyrene (16%)	3.1% energy consumption 4% GWP
Kitchen	4% of weight	Cardboard (97.2%) Polyester polyethylene-furanoate (PEF) (1%) Polystyrene (1.8%)	2.8% energy consumption 14.1% of acidification
Desk	15% of weight	Cardboard (90%) Polystyrene (7%) Polypropylene (3%)	6.3% energy consumption
Cabinet 2	17% of weight	Cardboard (92.5%) Polystyrene (7.5%)	8.3% energy consumption 13.4% acidification

5.4. Distribution

The distribution stage refers to the distribution of the final furniture product from the manufacturer to the retailer and the final consumer. In the EU market, transport is usually done by road transport or boats.

In some LCA studies and EPDs, distribution is not included in the scope, since this stage is considered to be out of control of manufacturer. However, LCA studies considering distribution, show that the contribution to overall environmental impacts is about 6% (*see section 4.3.4.* Distribution and transport processes may have relevance in the impact categories of ozone depletion, acidification (14% of overall impact) and eutrophication (10% of overall impact)[94].

Nevertheless, this stage can be relevant if the finished product is imported from plants at long distances from the end-consumer. This is the case for the increasing percentage of furniture coming from low-cost economies..

Transport of raw materials or processed materials is normally included in the materials stage. In some cases, transport of finished components from suppliers to furniture manufacturers is also assesse

d. Sensitive analysis on the origin of finished components, show significant variations of impacts depending on the country of manufacturing. These differences not only come from transport, but also from the production stage and the technology used in different countries.

5.5. Use

Most LCA studies do not include the use stage in the environmental assessment, since it is assumed to not have significant impacts. Some studies include cleaning or maintenance during the use phase. Where use stage was considered it had negligible environmental impacts.

Processes that enlarge the lifespan of a furniture product are maintenance, remanufacturing or reuse. Enlarging the lifespan results in avoided impacts from the manufacturing of new furniture pieces.

The lifetime of products depends on several factors: the technical lifetime (how long they work for), the real lifetime (how long people expect to keep them) and the economic lifetime (cost of maintenance versus cost of replacement)[163].

A standard furniture has a lifespan of 30 years, which means that most often when furniture comes to the end of its life (usually less than 30 years) it still has residual life [164]. However, the average lifespan is 15 years. This fact indicates that extending the life of furniture is the best choice to save impacts derived from the manufacturing of new items. Design for durability and information to the user could contribute to extent the lifespan of furniture.

Fitness for use and ergonomics refer to whether a product fulfils the expectations with respect to its function and contributes to a healthy environment for the user. A product that is not fit for purpose or not comfortable will be replaced sooner. The same applies to safety standards.

Durability, fitness for use, ergonomics and safety depend on quality standards. There are standards at European level and also for the different Member States, from were durability criteria can be set (see section 2.2 European Standards)

Reparability is an important element with respect to the maintenance of furniture and its durability. Reparability depends on:

- -The ease of disassembly, which in turn depends on the way the parts or materials are connected/assembled (the type of glue, the use of screws or welding, etc.);
- -Availability of spare parts.

From LCA studies and EPDs, the average life span expected by type of furniture has been defined. In some studies processes of maintenance and cleaning have been defined as well.

Table 35. Average life span and maintenance operation by type of furniture

Furniture	Study	Life span	Maintenance
Desk	Ihobe guide[98]	20 years	1 cleaning/week 1cl of water/cleaning (wet rags) 10 l water/ life span
	Steelcase[114]	30 years	-
Office table	Steelcase[114]	30 years	-
School desk	SETAC[121]	8 years	-
Office chair/siento	Steelcase	30 years	-
	Ihobe guide[98]	10-15 years	1 cleaning/week 1cl of water/cleaning (wet rags) 5-7.8 l water/ life span
	Formway[122]	10 years	-

	PCRs /EPDs	15 years	One vacuum cleaning every 2 years. A textile change once in the maintenance period.
Table	PCR on tables	15 years	-
Cabinets	PCR on cabinets	10 years	-

5.6. End-of-life

According to statistics from the European Federation of Furniture Manufacturers (UEA) furniture waste in the EU accounts annually for more than 4% of the total municipal solid waste (MSW). 80-90% of this is incinerated or dumped in landfills, whereas the remaining part is recycled.[165].

Some furniture is reused or refurbished to have a second life instead of becoming waste. Re-using furniture is an important market. In the UK, 14% of desks, 14% of office chairs, 17% of sofas and 17% of all the dining tables reaching the 'end-of-life' are reused in some form every year[166].

According to the Waste Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008)[167] the preferable hierarchy for furniture waste should be:

1.Reusing
2.Recycling
3.Energy valorisation
4.Disposal to landfill

LCA selected studies showed than on average, end-of-life stage can have a contribution of 15% on average on the different key environmental impact indicators. In all studies with sensitive analysis among different waste treatment scenarios, options to recover furniture after use have always great potential to reduce the environmental impacts. Recycling furniture showed lower impacts than landfill. For those components non-recyclable energy valorisation has the lowest impact of the disposal routes.

Recyclability of furniture will depend on the recyclability of the used materials and the possibility to separate different components. Regarding materials, the recyclability potential and limitations can be defined in general terms as follows:

-Wood. In general wood can be recycled as sawn wood or sawdust to be used in wooden panels. Nevertheless treated wood can have limited recyclability.
-Wooden panels. Wooden panels have limited recyclability due to the presence of resins. For all Environmental Product Declaration (EPDs) on wooden panels, the waste treatment considered for panels is the energy valorisation in a biomass power plant since panels usually have a high heating value (17-18 MJ/kg aprox.)
-Metals. All metals are totally recyclable and they can be easily recycled.
-Plastics. Plastic can be recycled, although some plastics such as PCV or multilayer materials can have more limited recyclability.
-Glass. Some treated flat glasses such as laminated glass or mirrored glass can be difficult to recycle due to the presence of different materials layers (polymers or metals)

Reusing – Remanufacturing

A study estimated the energy and economic saving potential associated to reusing/refurbishing/re-manufacturing of non-wood chairs and a wood desks. The analysis has shown that reusing / refurbishing / remanufacturing furniture products like chairs and desks leads to both energy and economic savings.[168].

Waste & Resources Action Programme (WRAP)[169] has studied the environmental, economic and social benefits of reusing office furniture (desks and office chairs) and domestic furniture (sofas and dinning tables). The key environmental benefits associated with reuse, besides economic and social benefits, are quantified for each type of furniture:

Desks

- Savings of 0.2-0.4 tonnes of CO_2 eq per tonne of desks provided for direct reuse, when compared to landfill.

Office Chairs

- Providing 1 tonne of office chairs for direct reuse e.g. second-hand shop can result in a net GHG saving of 3 tonnes CO_2-eq. This is just over 35kg CO_2-eq per chair.
- Providing 1 tonne of office chairs to a preparation for reuse network can result in a net GHG saving of 2.6 tonnes CO_2-eq net. This is approximately 30kg CO_2-eq per chair.
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.

Sofas

- Providing 1 tonne of sofas for direct reuse e.g. second-hand shop can result in a net GHG saving of 1.45 tonnes CO_2-eq. This is approximately 55kg CO_2-eq per sofa.
- Providing 1 tonne of sofas to a preparation for reuse network can result in a net GHG saving of 1.05 tonnes CO_2-eq net. This is about 40kg CO_2-eq per sofa.
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.

Dining Tables

- Providing 1 tonne of dining tables for direct reuse e.g. second-hand shop results in net GHG emissions (as opposed to savings) of 0.38 tonnes CO_2 eq. This is approximately 10kg CO_2-eq per table. However, these are lower than landfill emissions (1 tonne CO_2 eq per tonne dining tables).
- Providing 1 tonne of dining tables to a preparation for reuse network can result in a net GHG emissions (as opposed to savings) of 0.76 tonnes CO_2 eq. This is approximately 20kg CO_2-eq per table. However, these are lower than landfill emissions (1 tonne CO_2 eq per tonne dining tables).
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.

5.7. Life-cycle costing considerations

Life cycle costing (LCC) is defined in the International Organization for Standardization standard, *Buildings and Constructed Assets, Service-life Planning, Part 5: Life-cycle Costing* (ISO 15686-5) as an "economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability."

In the context of green public procurement (GPP), the use of LCC is essential to demonstrate that procurement processes and decisions have to move beyond considering the purchase price of a good or service. The purchase price alone does not reflect the financial and non-financial gains that are offered by environmentally and socially preferable assets as they accure during the operations and use phases of the asset life cycle.

"Green" and socially-preferable assets may carry considerably higher purchasing price tags than their less sustainable substitutes. This is particularly the case in middle- and lower-income countries where the markets for green and social goods and services are in their infancy. It is true that the price premiums paid for sustainable assets may be largely offset through efficiency gains, cost savings and lowered risks during the product/project lifetime.

In some countries, the production of sustainable and LCC-efficient goods and services is just starting, which means that the only way to source sustainable alternatives will be through expensive imports or paying a very high cost premium to stimulate local industries. In lower income economies, differences on prices between conventional and green products can be higher, as much as 10 to 50 per cent. However, the large volumes demanded by public procurement contracts can make economies of scale more feasible, and the prices of these products can be expected to decrease as more producers enter the market[170].

LCC can be most feasibly applied to certain categories of products and services. The level of applicability of life cycle costing for furniture is considered moderately applicable.

The results of taking a life-cycle approach for purchasing decisions has been well documented for products such as electrical appliances, where an energy efficient version will cost less over the longer term due to reduced energy costs. Unfortunately there has been comparatively little work done on quantifying the lifecycle costing of office furniture.

The EU study "Costs and Benefits of Green Public Procurement in Europe" evaluated the cost difference between green and non-green products in the furniture sector. Three pieces of furniture have been selected for price comparison between 4 countries (i.e. Sweden, Germany, Spain and Czech Republic): mobile cabinets, open storage units and office chairs.

Green products were defined as those certified with the Nordic Swan, Blue Angel, AENOR, Czech flower and Austrian ecolabels. Prices differences can be found in Table 36.[171]

Table 36. Differences in purchasing cost for green and non-green furniture.

Cost of mobile cabinets in Euros (incl. VAT)				
	Costs		**Differences**	
	Non-green version	Green version	Absolute	Relative
SV	174	236	62	36%
DE	223	201	-22	-10%
ES	129	219	90	70%
CS	142	225	83	58%

Cost of open storage units in Euros (incl. VAT)				
	Costs		**Differences**	
	Non-green version	Green version	Absolute	Relative
SV	433	437	4	1%
DE	226	462	236	104%
ES	223	451	228	102%
CS	143	162	19	13%

Cost of office chairs in Euros (incl. VAT)				
	Costs		**Differences**	
	Non-green version	Green version	Absolute	Relative
SV	335	398	62.5	19%
DE	295	355	59.5	20%
ES	311	369	58	19%
CS	319	378	59.5	19%

The study showed for almost all product types and selected Member States that green versions are more expensive than non-green versions (the only exception are mobile cabinets in Germany). However, in all cases a very big variety of different products exist, making it difficult to find two products which are functionally identical with the exception of the compliance with environmental criteria. The price differences, therefore, might also reflect differences in quality or fitting that may have a greater influence than differences between green and non-green versions.

For a single piece of furniture the most significant cost by far will be the purchase price (although disposal of large items may also involve some costs). However, the frequency of replacement also needs to be carefully considered – if a more expensive product lasts three times as long as a cheap model then it will likely prove economical in the long run[92].

6. ANALYSIS OF HAZARDOUS SUBSTANCES USED IN FURNITURE SECTOR ACCORDING TO REACH REGULATION (EC) 1907/2006 CONCERNING THE REGISTRATION, EVALUATION, AUTHORISATION AND RESTRICTION OF CHEMICALS

6.1. Introduction

The Regulation (EC) 1907/2006, mainly known as REACH, concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals, entered into force on 1st June 2007. REACH does not allow placing on the market substances on their own, in mixtures and in certain cases in articles in quantities equal or superior to 1 tonne per year if they have not been registered by every legal entity that manufactures or imports outside the European Union. REACH will be gradually implemented in the European Economic Area[172] through a phased approach with a timeline that extends until June 2018.

The Regulation (EC) 1272/2009 on classification, labelling and packaging of substances and mixtures (CLP), entered into force on 20th January 2009 and is based on the United Nations' Globally Harmonised System (GHS). The CLP Regulation ensures that the hazards of chemicals are properly communicated to workers and consumers in the European Union through classification and labelling of chemicals by standard statements and pictograms on labels and safety data sheets. Before placing chemicals on the market, the industry must establish the potential risks to human health and the environment of substances and mixtures, classifying them in line with the identified hazards. Like REACH, the requirements in CLP will be gradually implemented and replace the Council Directive 67/548/EEC[173] as well as Directive 1999/45/EEC[174]. The date from which substances classification and labelling must be consistent with CLP was December 2010 and for mixtures will be June 2015. Then the CLP Regulation will fully replace the DSD[175] and DPD[176]. Therefore, identification of hazardous substances for furniture will focus on substances classified under CLP regulation.

The aim of REACH and CLP is to ensure a high level of protection of human health and the environment from the risks that can be posed by chemicals, as well as promote alternative methods for the assessment of the hazards of substances and ensure the free movement of registered substances along the EEA[15] while enhancing the competitiveness of the EU chemicals industry.

Moreover, REACH and CLP place greater responsibility on industry to manage the risks that chemicals may pose to the health and the environment, as well as to provide sufficient information on the safety of the products that would be communicated through the supply chain. Manufacturers and importers will be required to identify and manage risks linked to the substances they manufacture and/or import in quantities of 1 tonne or more per year. To ensure that they actually meet these obligations, a registration process should require them to submit a dossier jointly containing this information to ECHA[16]. In addition, communication of technical advice to support risk management should be encouraged throughout the supply chain to other professionals such as downstream users or distributors to meet their responsibility in relation to the management of risks arising from the identified uses of substances. They have to demonstrate to ECHA how the substance can be safely used and they must communicate the risk management measures to the users.

Obligations under REACH are determined by the company's role: manufacturer, importer, downstream user or distributor. Mainly, furniture manufacturers are defined, according to REACH, as:

[15] European Economic Area

[16] ECHA: European Chemicals Agency based in Helsinki.

- ***Downstream users*** because they use substances and/or mixtures for finishing treatments (surface treatments). These include substances used to treat, preserve, paint, remove paint, varnish, stain, lacquer, clean, seal and glue furniture and wood products

  and/or

- ***Article producers*** because according to Article 3 (4) of the REACH regulation, they make or assemble an article within the European Economic Area (EEA).

In the case of substances of very high concern, the authorisation process will ensure the good functioning of the internal market while assuring that their risks are properly controlled and these substances are progressively replaced by suitable alternative substances or technologies where these are economically and technically viable[177]. To this end, all manufacturers and importers shall apply for authorisation of substances included in Annex XIV and it should be granted by the Commission only if the risks arising from their use are adequately controlled or the use can be justified for socio-economic reasons and no suitable alternatives are available. In the case that the risks cannot be managed, authorities can restrict partially or totally the use of these substances of concern. The companies that do not undertake this procedure will not be able to manufacture, sell or use their products and would consequently be forced to stop their activity.

Certain substances of concern may be subject to controls under the Authorisation process of REACH. The following criteria will be used to identify substances of very high concern:

- Substances that stay in the environment for a long time, build up in the tissue of animals and cause some form of harmful effect (persistent, bioaccumulative and toxic – PBT) , or those that stay in the environment for a very long time and build up in the tissue of animals very readily (very persistent, very bioaccumulative – vPvB).
- Those substances which can cause cancer, genetic mutations or cause reproductive problems (these substances will have at least one of the following the following CLP Hazard statements H350, H350i, H340, H360F, H360D, H360FD, H360Df, H360Fd; risk phrases R45, R49, R46, R60, R61.
- Substances that cause similarly serious effects to those above e.g. those having endocrine disrupting properties (i.e. chemicals which mimic hormones and disrupt the function of hormones that occur naturally in people and animals), or those for which there is scientific evidence of probable serious effects to human health or the environment giving rise to an equivalent level of concern to those of other substances listed above.

Currently[17], there are 144 substances on the candidate list[178] of substances of very high concern for authorisation. ECHA prioritises the substances from the Candidate List to determine which ones should be included in the Authorisation List (Annex XIV of REACH) and therefore, subject to authorisation. This prioritisation is primarily based on intrinsic properties, volumes and dispersive uses of substances on the EU market.

On 17 February 2011[179], the European Commission named 6 chemicals as the first entrants on the Authorization List (Annex XIV), afterwards on 14 February 2012[180], eight more substances of very high concern were added to the list and finally on 17 April[181] this year the European Commission approved 8 new substances in the Annex XIV of REACH.

Nowadays, there are a total of 22 substances subjected to authorization included in Annex XIV:

[17] Last updated 20th June 2013

Table 37. Authorisation list

SUBSTANCE NAME	EC NUMBER	CAS NUMBER	SUNSET DATE	LATEST APPLICATION DATE	REASON FOR INCLUSION IN THE AUTHORISATION LIST
Ammonium dichromate	232-143-1	2151163	21/09/2017	21/03/2016	Carcinogenic, mutagenic and toxic for reproduction
Potassium chromate	232-140-5	7789-00-6	21/09/2017	21/03/2016	Carcinogenic and mutagenic
Acids generated from chromium trioxide and their oligomers Group containing: Chromic acid, Dichromic acid, Oligomers of chromic acid and dichromic acid	231-801-5, 236-881-5	7738-94-5, 13530-68-2	21/09/2017	21/03/2016	Carcinogenic
Chromium trioxide	215-607-8	1333-82-0	21/09/2017	21/03/2016	Carcinogenic and mutagenic
Potassium dichromate	231-906-6	7778-50-9	21/09/2017	21/03/2016	Carcinogenic, mutagenic and toxic for reproduction
Sodium chromate	231-889-5		21/09/2017	21/03/2016	Carcinogenic, mutagenic and toxic for reproduction
Sodium dichromate	234-190-3	7789-12-0; 10588-01-9	21/09/2017	21/03/2016	Carcinogenic, mutagenic and toxic for reproduction
Trichloroethylene	201-167-4	79-01-6	21/04/2016	21/10/2014	Carcinogenic
Hexabromocyclododecane (HBCDD), alpha-hexabromocyclododecane, beta-hexabromocyclododecane, gamma-hexabromocyclododecane	221-695-9, 247-148-4	3194-55-6, 25637-99-4, 134237-50-6, 134237-51-7, 134237-52-8	21/08/2015	21/02/2014	PBT
2,4 - Dinitrotoluene (2,4-DNT)	204-450-0	121-14-2	21/08/2015	21/02/2014	Carcinogenic
Tris(2-chloroethyl)phosphate (TCEP)	204-118-5	115-96-8	21/08/2015	21/02/2014	Toxic for reproduction
Diarsenic pentaoxide	215-116-9	1303-28-2	21/05/2015	21/11/2013	Carcinogenic
Lead sulfochromate yellow (C.I. Pigment Yellow 34)	215-693-7	1344-37-2	21/05/2015	21/11/2013	Carcinogenic and toxic for reproduction
Lead chromate molybdate sulphate red (C.I. Pigment Red 104)	235-759-9	12656-85-8	21/05/2015	21/11/2013	Carcinogenic and toxic for reproduction
Diarsenic trioxide	215-481-4	1327-53-3	21/05/2015	21/11/2013	Carcinogenic
Lead chromate	231-846-0	7758-97-6	21/05/2015	21/11/2013	Carcinogenic and toxic for reproduction
Benzyl butyl phthalate (BBP)	201-622-7	85-68-7	21/02/2015	21/08/2013	Toxic for reproduction
Bis(2-ethylhexyl) phthalate (DEHP)	204-211-0	117-81-7	21/02/2015	21/08/2013	Toxic for reproduction
Dibutyl phthalate (DBP)	201-557-4	84-74-2	21/02/2015	21/08/2013	Toxic for reproduction

SUBSTANCE NAME	EC NUMBER	CAS NUMBER	SUNSET DATE	LATEST APPLICATION DATE	REASON FOR INCLUSION IN THE AUTHORISATION LIST
Diisobutyl phthalate (DIBP)	201-553-2	84-69-5	21/02/2015	21/08/2013	Toxic for reproduction
5-tert-butyl-2,4,6-trinitro-m-xylene (Musk xylene)	201-329-4	81-15-2	21/08/2014	21/02/2013	vPvB
4,4-Diaminodiphenylmethane (MDA)	202-974-4	101-77-9	21/08/2014	21/02/2013	Carcinogenic

Source: European Chemicals Agency website

According to the Article 6(6) of EU Ecolabel legislation EC/66/2010[182], the product or any part of it thereof shall not contain substances or mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with CLP Regulation (EC) No 1272/2008, nor to goods containing substances referred to in Article 57 of REACH Regulation. Hazardous substances can be classified through the hazard statements provided in Appendix IV of this report.

6.2. Methodology

The main objective is to carry out a study of the furniture environmental performance during their entire life cycle, identifying the areas with the highest environmental impact and taking into account the potential minimization or substitution of hazardous substances according to REACH regulation as a basis.

According to the figure below, all relevant identified environmental and human health impacts will be dealt with in the process of the criteria setting aimed at promoting sustainable production and consumption:

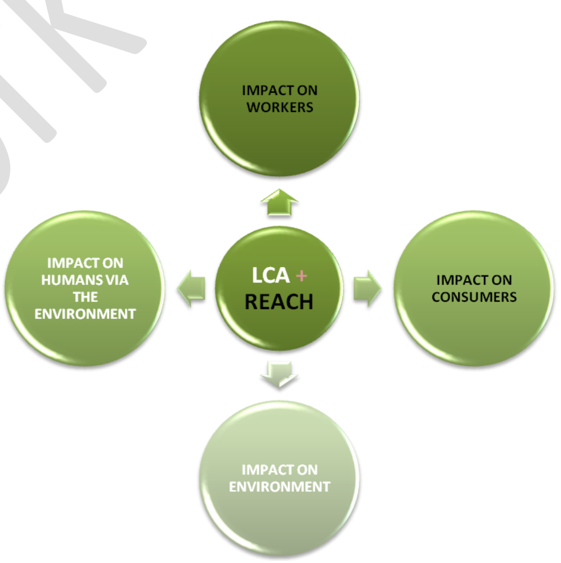


Figure 37. Methodology approach based on LCA and REACH

On the one hand, Life Cycle Assessment allows characterizing over the entire life cycle of the product the environmental sustainability. This involves the production of the product, the development of the product, the manufacturing process and the end-of-life options, taking into account eco-design actions. On the other hand, the analysis of hazardous substances used in the furniture sector according to REACH regulation is carried out. The REACH analysis specifically takes into account the identification of hazardous substances in particular with regard to substances of very high concern (Annex XIV) and the candidate list for authorisation. According to this, focus on substances of very high concern (Annex XIV of REACH Regulation[183]) and the candidate list for authorisation[18] as referred in REACH Regulation was given.

The REACH analysis follows the following stepwise approach:

Phase 1: Identification of substances and mixtures used in the furniture production processes

Analysis of the most common chemical substances present in the products (mainly for surface treatments) and their function has been carried out.

The furniture sector is closely linked to other sectors subjected to REACH regulation such as paints, varnishes, inks, glues, foams, biocides such as fungicides, insecticide, etc. This will require an understanding of the exact use of the substances including a description and outcome of the process where the use is applied.

A detailed and specific knowledge of the exact function for a particular use will allow looking for other ways of performing that function. This may be done using another substance or technology or by changing the process or end product.

Phase 2: Obtaining information on composition (Safety Data Sheets)

Information of the characteristics of different products existing on the market has been gathered in order to do a preliminary analysis of the most common substances used. For this analysis, information from literature, as well as a compilation of Safety Data Sheets and stakeholder and trade/sector organisations´ knowledge, is collected.

Representativeness has been taken into account, so that different kinds of furniture products included in the category have been studied.

The Safety Data Sheet (SDS) contains information which can be used for considerations of composition of substances and substitution. Essential information includes physicochemical data as well as toxicological and ecotoxicological information. All information relevant to the prevention of damage to human health and the environment must be included.

The objective of the SDS is to ensure that manufacturers, importers and downstream users have enough information to use chemical substances safely. The supplier must provide a SDS if the substance or preparation is hazardous, PBT (persistent, bioaccumulative and toxic) or vPvB (very persistent and very bioaccumulative) or is on the candidate list of substances of very high concern (SHVC).

Exposure scenarios will be annexed to the SDS providing information to the users about the risk management measures that have to be implemented or recommended by the manufacturers for safe uses of the substance. The SDS must be updated if an authorisation is granted or refused, a restriction is imposed or even new information on hazards properties becomes available.

Until CLP regulation[184] entered into force, different classifications of the same substances appeared in the safety data sheets. For this reason, we chose to use a harmonized classification based on information from the list of harmonized classification (according to Annex VI of CLP regulation, table 3.1: List of harmonised classification and labelling of hazardous subtances). If a specific substance does not have a harmonized classification, we will use commonly recognized tools such as ESIS[185] and information extracted from registered substances from ECHA[186]. The Classification & Labelling (C&L) Inventory[187] from ECHA is a database that contains basic classification and labelling

[18] For more information see appendix I of this report

information on notified and registered substances received from manufacturers and importers; however, ECHA does not verify the accuracy of the information introduced in the Classification & Labelling (C&L) Inventory.

Phase 3: Assessing the risk

Based on the information provided by the list of harmonized classification according to Annex VI of CLP regulation, ESIS and ECHA[188], a **priority list of hazardous substances present on the most common materials as well as used in the furniture production processes** (mainly surface treatments), which are determined to pose the most significant potential threat to human health and environment has been prepared.

It is important to remember that less dangerous chemicals are not necessarily harmless. Therefore, risk management measures are still needed in many cases.

Some other sources of information such as literature and/or databases have been taken into account, e.g. the hazardous substances database PRIO developed by KEMI[189] (Swedish Chemicals Agency).

6.3. Identification of substances in the furniture sector

The main substances identified that are used for furniture are:

- Biocides (fungicides, insecticides): are used for the protection and preservation of wood. The ultimate goal is to extend the useful lifespan since an organic material tends to decompose by the action of bacteria and microorganisms, especially under outdoor environmental conditions with changes in temperature and humidity
- Flame retardants: are a variety of compounds added to materials to reduce their flammability or to delay the propagation of the flame, in order to prevent fires.
- Waterproof protective (waxes, paraffin
- Adhesives, resins and glues Adhesives are used in the production of wooden panels as well as in the assembly of furniture. Different types of adhesives are on the market which can be natural or synthetic (petroleum based adhesives):
  - **Natural adhesives are also called glues**: *Natural adhesives* are made from organic sources such as vegetable matter, starch (dextrin), natural resins or from animals e.g. casein or animal glue. They are often referred to as bioadhesives:
    - Animal glues: often called “hot blue” are made from hides, bones and other parts of cattle.
    - Starch (vegetable) glues: made from cassava starch in water. They can be applied hot or cold.
    - Casein: is formulated from protein (curds) obtained from milk.
    - Other naturals: soybean and blood. They are similar to vegetable and casein and are used primarily for veneer gluing.
  - **Synthetic adhesives**: These are organized into reactive and non-reactive adhesives, which refers to if the adhesive chemically reacts to harden.
    - **Reactive adhesives:**
      - ✓ **Thermosetting adhesives**: which require heat to cure. They often contain formaldehyde as a major ingredient. Examples: urea, urea-formaldehyde resins, phenol-formaldehyde resins, resorcinol and phenol-resorcinol, melamine resins and epoxy cyanoacrylate.
      - ✓ **Thermoplastic adhesives**: which undergo irreversible chemical curing reactions to produce the glue joint. Examples:

thermoplastic hot melts (using polyethylene and polypropylene) and polyvinyl-acetate (PVA).
  - ✓ **Elastomers**
  - ✓ **Emulsions**
- **Non-reactive adhesives**: Those that do not chemically cure and, therefore, may soften with heat.

- Hardeners: A hardener or setting agent is usually required to convert synthetic adhesives from liquid to solid.
- Additives
- Paints, varnishes and inks
- Foams
- Plasticers, stabilisers and anti-oxidants
- Nanomaterials

The identification of the different substances will be described relating to the different materials to which they are applied. In appendix V you can find an overview of the production stage where they are applied.

6.3.1. Wood

The addition of chemical substances such as biocides, flame retardants, resins, adhesives, paints, etc. are applied to the wooden materials in order to obtain the final article.

6.3.1.1. Biocides

Various agents of biocides can be used for the protection and preservation of wood. The ultimate goal is to extend the useful lifespan since an organic material tends to decompose by the action of bacteria and microorganisms, especially under outdoor environmental conditions with changes in temperature and humidity. Different compounds used to preserve wood can be applied in different ways. The most common ways of application are sprinkling, immersion and autoclave.

Tributyltin compounds were the main active ingredients in certain biocides to control a broad spectrum of organisms. Uses include wood preservation, antifouling pesticide in marine paints and antifungal action in textiles. However, this use is now prohibited in the EU as it was not notified under the Biocidal Products Directive.

These compounds are included in the Rotterdam Convention. TBT compounds are considered toxic chemicals which have negative effects on human and environment. In addition, TBT compounds elicit effects in the endocrine systems of aquatic organisms and are moderately to highly persistent organic pollutants causing irreversible damage to the aquatic life.

Bis(tributyltin) oxide (TBTO) was identified as a Substance of Very High Concern (SVHC) meeting the criteria of a PBT substance pursuant to Article 57 (d) and was therefore included in the candidate list for authorization. TBTO is currently only used in the EU as an intermediate for manufacture of other chemicals. According to the background document for bis(tributyltin) oxide (TBTO)19, in 2001, TBT concentrations in water and sediment were 3.62 mg/L and 10.8 mg/kg respectively, with maximum concentration of 53 mg/kg TBT in harbours (Norwegian Competent Authority, 2008). However, due to strongly reduced uses of TBT, also declining trends in sediment TBT concentrations were

[19] Document developed in the context of ECHA´s first recommendation for the inclusion of substances in Annex XIV, more information available online at: http://echa.europa.eu/documents/10162/0ba7c534-4ffa-4b66-b773-653015869d01

identified, e.g. in many German rivers, TBT sediment concentrations were already below 0.005 mg/kg in 2003 (Norwegian Competent Authority, 2008).

The Biocidal Products Regulation (BPR, Regulation (EU) 528/2012)[190] concerns the placing on the market and use of biocidal products which are used to protect humans, animals, materials or articles against harmful organisms like pests or bacteria, by the action of the active substances contained in the biocidal product. This regulation on the use and placing on the market of biocidal products will repeal and replace the current directive on biocides (Directive 98/8/EC). It has entered into force on 1 January 2013 and will be applicable from 1 September 2013, with a transitional period for certain provisions. According to this, all biocidal products require an authorisation before they can be placed on the market, and the active substances contained in that biocidal product must be previously approved by product type. Wood preservatives are covered under Product type 8 in the Regulation and are defined as: products used for the preservation of wood, from and including the sawmill stage or wood products by the control of wood-destroying or wood-disfiguring organisms. This product type includes both preventive and curative products. The European Commission includes approved active substances in a list of approved active substances (formerly Annex I of Directive 98/8/EC)[191]. The European Commission keeps the list updated and electronically available to the public. Currently[20], the list of approved substances to be used for product type 8 is:

Table 38. List of approved substances to be used for product type 8: wood preservatives

PRODUCT TYPE 8: WOOD PRESERVATIVES						
Active substance	**EC number**	**CAS number**	**Inclusion Directive**	**Classification**		**Specific Conc. Limits, M-factors**[192]
				Hazard Class	**Hazard Statement**	
Basic Copper carbonate	235-113-6	12069-69-1	2012/2/EU	*Not classified*		
Bifenthrin	n/a	82657-04-3	2011/10/EU	*Not classified*		
Boric acid	233-139-2	10043-35-3	2009/94/EC	Toxic for reproduction (article 57 c) according Candidate List		
				Repr. 1B	H360FD	Repr. 1B; H360FD: C ≥ 5,5 %
Boric oxide	215-125-8	1303-86-2	2009/98/EC	Repr. 1B	H360FD	Repr. 1B; H360FD: C ≥ 3,1 %
Clothianidin	433-460-1	210880-92-5	2008/15/EC	*Not classified*		
Copper (II) hydroxide	243-815-9	26427-59-2	2012/2/EU	*Not classified*		
Copper (II) oxide	215-269-1	1317-38-0	2012/2/EU	*Not classified*		
DDACarbonate	451-900-9	894406-76-9	2012/22/EU	*Not classified*		
Dazomet	208-574-7	533-74-4	2010/50/EU	*Not classified*		
DCOIT (4,5-Dichloro- 2-octyl-2H-isothiazol-3-one)	264-843-8	64359-81-5	2011/66/EU	*Not classified*		
Dichlofluanid	214-118-	1085-98-	2007/20/EC	Acute Tox. 4	H332 H319	M=10

[20] Last updated: 12th February 2013

PRODUCT TYPE 8: WOOD PRESERVATIVES						
Active substance	EC number	CAS number	Inclusion Directive	Classification		Specific Conc. Limits, M-factors[192]
				Hazard Class	Hazard Statement	
	7	9		Eye Irrit. 2 Skin Sens. 1 Aquatic Acute 1	H317 H400	
Disodium octaborate tetrahydrate	234-541-0	12280-03-4	2009/96/EC	*Not classified*		
Disodium tetraborate	215-540-4	1330-43-4	2009/91/EC	Repr. 1B	H360FD	Repr. 1B; H360FD: C ≥ 4,5 %
Creosote	232-287-5	8001-58-9	2011/71/EU	Carc.1B	H350	
Etofenprox	407-980-2	80844-07-1	2008/16/EC	*Not classified*		
Fenoxycarb	276-696-7	72490-01-8	2011/12/EU	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	
Fenpropimorph	266-719-9	67564-91-4	2009/86/EC	Repr. 2 Acute Tox. 4 Skin Irrit. 2 Aquatic Chronic 2	H361d H302 H315 H411	
Flufenoxuron	417-680-3	101463-69-8	2012/20/EU	*Not classified*		
IPBC	259-627-5	55406-53-6	2008/79/EC	*Not classified*		
K-HDO	n/a	66603-10-9	2008/80/EC	*Not classified*		
Propiconazole	262-104-4	60207-90-1	2008/78/EC	Acute Tox. 4 Skin Sens. 1 Aquatic Acute 1 Aquatic Chronic 1	H302 H317 H400 H410	
Sulfuryl fluoride	220-281-5	2699-79-8	2006/140/EC	Press. Gas Acute Tox. 3 STOT RE 2 Aquatic Acute 1	H331 H373 H400	
Tebuconazole	403-640-2	107534-96-3	2008/86/EC	Repr. 2 Acute Tox. 4 Aquatic Chronic 2	H361d H302 H411	
Thiabendazole	205-725-8	148-79-8	2008/85/EC	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	
Thiacloprid	n/a	111988-49-9	2009/88/EC	*Not classified*		
Thiamethoxam	428-650-4	153719-23-4	2008/77/EC	Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 1	H302 H400 H410	M=10
Tolylfluanid	211-986-9	731-27-1	2009/151/EC	Acute Tox. 2 STOT RE 1 Eye Irrit. 2 STOT SE 3 Skin Irrit. 2	H330 H372 H319 H335 H315 H317 H400	M=10

PRODUCT TYPE 8: WOOD PRESERVATIVES						
Active substance	EC number	CAS number	Inclusion Directive	Classification		Specific Conc. Limits, M-factors[192]
				Hazard Class	Hazard Statement	
				Skin Sens. 1 Aquatic Acute 1		

Source: European Commission website

Product type 18 of the biocide regulation includes insecticides, acaricides and products to control other arthropods. These types of products are used for the control of arthropods like insects, arachnids and crustaceans by means other than repulsion or attraction. Currently[21], the list of approved substances to be used for product type 18 is:

Table 39. List of approved substances to be used for product type 18: insecticides, acaricides and products to control other arthropods

PRODUCT TYPE 18: INSECTICIDES, ACARICIDES AND PRODUCTS TO CONTROL OTHER ARTHROPODS						
Active substance	EC number	CAS number	Inclusion Directive	Classification		Specific Conc. Limits, M-factors[193]
				Hazard Class	Hazard Statement	
Abamectin	n/a	71751-41-2	2011/67/EU	Acute tox.2 Acute tox. 1 Repr. 2 STOT RE 1 Aquatic Acute 1 Aquatic Chronic 1	H300 H330 H361d H372 H400 H410	STOT RE 1; H372: C ≥ 5% STOT RE 2; H373: 0,5% ≤ C < 5% M=10000
Aluminium phosphide releasing phosphine	244-088-0	20859-73-8	2010/9/EU	Water-react. 1 Acute Tox. 2 Aquatic Acute 1	H260 H300 H400	M=100
Bacillus thuringiensis subsp. israelensis Serotype H14, Strain AM65-52	n/a	n/a	2011/78/EU	n/a		
Bendiocarb	245-216-8	22781-23-3	2012/3/EU	Acute Tox. 3 Acute Tox. 3 Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 1	H331 H301 H312 H410	
Carbon dioxide	204-696-9	124-38-9	2010/74/EU	*Not classified*		

[21] Last updated: 12th February 2013

PRODUCT TYPE 18: INSECTICIDES, ACARICIDES AND PRODUCTS TO CONTROL OTHER ARTHROPODS						
Active substance	**EC number**	**CAS number**	**Inclusion Directive**	**Classification**		**Specific Conc. Limits, M-factors**[193]
				Hazard Class	**Hazard Statement**	
Deltamethrin	258-256-6	52918-63-5	2011/81/EU	Acute Tox. 3 Acute Tox. 3 Aquatic Acute 1 Aquatic Chronic 1	H331 H301 H400 H410	M=1000000
Fipronil	424-610-5	120068-37-3	2011/79/EU	*Not classified*		
Imidacloprid	428-040-8	138261-41-3	2011/69/EU	Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 1	H302 H400 H410	
Indoxacarb	n/a	173584-44-6	2009/87/EC	n/a		
Lambda-cyhalothrin	415-130-7	91465-08-6	2011/80/EU	Acute Tox. 2 Acute Tox. 3 Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 1	H330 H301 H312 H400 H410	M=10000
Magnesium phosphide releasing phosphine	235-023-7	12057-74-8	2010/7/EU	Water-react. 1 Acute Tox. 2 Aquatic Acute 1	H260 H300 H400	M=100
Margosa extract	283-644-7	84696-25-3	2012/15/EU	*Not classified*		
Metofluthrin	n/a	240494-70-6	2010/71/EU	*n/a*		
Nitrogen	231-783-9	7727-37-9	2009/89/EC	*Not classified*		
Spinosad	434-300-1	168316-95-8	2010/72/EU	*Not classified*		
Sulfuryl fluoride	220-281-5	2699-79-8	2009/84/EC	Press. Gas Acute Tox. 3 STOT RE 2 Aquatic Acute 1	H331 H373 H400	

Source: European Commission website

Only biocidal products containing biocidal active substances approved by European Commission and authorised for use in wood are allowed for use.

Based on the list of approved substances to be used for product types 8 and 18, the identification of substances of concern is based on its inherent hazardous properties to environment and human health according to the harmonised classification set up in Annex VI, table 3.1 of CLP regulation.

The main substances of concern found in product types 8 and 18 are highlighted in **yellow colour**. The different substances in the tables show that there are other environmentally preferable alternatives.

The major environmental problem associated with the use of biocides is the contamination of soil and drained water from spills and timber after processing. If the wood protection product is accidentally leaked or washed out, it can reach the ground and the surrounding terrain, which may even reach the water underground, which would cause a major environmental problem, since they often are used as source of drinking water for people and animals, as well as for irrigation of farmlands. Similarly, at the product's end of life, the substances present in the timber may prevent the use of waste as material premium in other applications, or generate leachate that contaminates both soil and groundwater.

Pentachlorophenol (PCP) was used for its properties as biocidal agent in wood products. According to its harmonized CLP classification: Carc. 2 Acute Tox. 2 * Acute Tox. 3 * Acute Tox. 3 * Eye Irrit. 2 STOT SE 3 Skin Irrit. 2 Aquatic Acute 1 and Aquatic Chronic 1, there is considerable concern about adverse ecosystem effects in areas of PCP contamination. PCP has been detected in surface waters and sediments, rainwater, drinking water, aquatic organisms, soil, and food, as well as in human milk, adipose tissue, and urine. Releases to the environment are decreasing as a result of declining consumption and changing use methods. However, PCP is still released to surface waters from the atmosphere by wet deposition, from soil by run off and leaching, and from manufacturing and processing facilities. PCP is released directly into the atmosphere via volatilization from treated wood products and during production. Finally, releases to the soil can be by leaching from treated wood products, atmospheric deposition in precipitation (such as rain and snow), spills at industrial facilities and at hazardous waste sites.

After PCP is released into the atmosphere it decomposes through photolysis. The main biodegradative pathway for PCP is reductive dehalogenation. In this process, the compound PCP is broken down to tetrachlorophenols, trichlorophenols, and dichlorophenols. PCP was finally banned in 1987 for this use.In a parallel way, dimethylfumarate (DMFu) as a biocide is not allowed in the EU according to decision 2009/251/EC. DMFu being present either in the articles themselves or in sachets added to the articles seem to have caused many of the observed cases of DMFu-sensitisation. A number of cases of DMFu in articles have been reported via the EU rapid alert system for dangerous consumer products, the RAPEX system. Some of the identified health effects from the use of DMFu in sofas are serious burns, eye problems and breathing difficulties.

6.3.1.2. Flame retardants

Flame-retardants are a variety of compounds added to materials to reduce their flammability or to delay the propagation of the flame, in order to prevent fires. Flame retardants have been used extensively in the passive protection of wood, plastics, textile and synthetic fibres. Some of the main flame retardants contain halogenated organic compounds, e.g. polychlorinated polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDEs), tetrabromobisphenol A (TBBPA) and hexabromocyclododecane (HBCDD). Although they have been widely used by industry, recent studies warn on environmental issues and toxicity of these compounds, or that it is advisable to use flame retardants containing no halogenated compounds.

Environmental problems associated with the use of flame retardants can arise either during the production process, migration of the material under certain conditions (evaporation) or downloads or waste water treatment, or during the disposal or recycling stage since products can emanate generate toxic gases or corrosive decomposition. Hydrophobic properties enable PBBs to be readily absorbed from the soil into aqueous solutions. Once released into the environment, PBBs can enter the food chain and be bio-concentrated by certain organisms[98]

Based on the precautionary principle, some specific substances which rise environmental or health related concern must be discussed and considered to be specifically excluded or restricted in the product group under study. They are briefly presented below:

Table 40. Main flame retardants included in the candidate and authorisation list

SUBSTANCE NAME	EC NUMBER	CAS NUMBER	REASON FOR INCLUSION		CLP Classification	
					Hazard Class	Hazard Statement
Hexabromocyclododecane (HBCDD), alpha-hexabromocyclododecane, beta-hexabromocyclododecane, gamma-hexabromocyclododecane	221-695-9, 247-148-4	3194-55-6, 25637-99-4, 134237-50-6, 134237-51-7, 134237-52-8	PBT	**AUTHORISATION LIST (ANNEX XIV OF REACH)**	The substance has not harmonized classification according to CLP regulation. Members of EBFRIP (European Brominated Flame Retardant Industry Panel) are implementing the classification: Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410) for HBCDD products	
Tris(2-chloroethyl)phosphate (TCEP)	204-118-5	115-96-8	Toxic for reproduction		Carc. 2 Repr. 1B Acute Tox. 4 Aquatic Chronic 2	H351 H360FH302 H411
Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins -SCCP)	287-476-5	85535-84-8	PBT and vPvB (articles 57 d and 57 e)	**CANDIDATE LIST**	Carc. 2 Aquatic Acute 1 Aquatic Chronic 1	H351 H400 H410
Bis(pentabromophenyl) ether (decabromodiphenyl ether; DecaBDE)	214-604-9	1163-19-5	PBT (Article 57 d); vPvB (Article 57 e)		See table below	

Source: ECHA website

According to Table 40, bis(pentabromophenyl) ether (decabromodiphenyl ether (DecaBDE), is not listed in Annex VI of the CLP Regulation according to harmonized classifications. The 2nd ATP to the CLP regulation introduced additional classification criteria based on long-term aquatic hazard data. However, these do not affect the classification of the substance in view of the lack of any observed chronic toxicity in standard aquatic tests up to water solubility limit. Some self-classifications that have been notified to the CLP inventory are:

Table 41. Self-classifications of DecaBDE notified to the CLP inventory

CLASSIFICATION		NUMBER OF NOTIFIERS	JOINT ENTRIES
HAZARD CLASS	HAZARD STATEMENT		
Not classified		163	√
Acute tox.4 Acute tox 4 Eye irrit 2 Acute tox 4	H302 H312 H319 H302	28	X
Acute tox 4	H312	23	X
Acute tox 4 Muta 2 STOT RE 2	H332 H341 H373	14	X
Aquatic Chronic 4	H413	19	X

Source: ECHA website

Certain **halogenated organic flame retardants** such as Hexabromocyclododecane (HBCDD) and all major diastereoisomers and Tris(2-chloroethyl)phosphate (TCEP) are classified as PBT (persistent, bioaccumulative and toxic) and toxic for reproduction respectively according to the authorisation list for substances of very high concern. Furthermore, short-chain chlorinated parraffins and Bis(pentabromophenyl)ether (DecaBDE) are included in the candidate list of substances of very high concern being classified as PBT (persistent, bioaccumulative and toxic) and vPvB (very persistent, very bioaccumulative).

Short-chain chlorinated paraffins and brominated flame retardants are also included in the list of chemicals requiring priority action of the OSPAR Strategy on Hazardous Substances .They have the potential to form polibrominated and polychlorinated dioxins and furans and many show persistent and bioaccumulative properties. Moreover, they have a very negative impact in the management of the end-of-life of the products, as they limit recycling and generate very hazardous substances when incinerated.

In general, halogenated organic compounds (containing chlorine, bromine, fluorine or iodine) encompass a large number of hazardous substances harmful to health and environment. Furthermore, the halogenated organic compounds do not degrade readily in the environment which increases the risk to harmful effects.

6.3.1.3. Adhesives and resins

Adhesives are used in the production of wooden panels as well as in the assembly of furniture. Different types of adhesives are on the market which can be natural or synthetic (petroleum based adhesives). Some of the synthetic adhesives and resins mainly used are:

- ✓ **Urea-formaldehyde resins (UF)** used in plywood, particleboard and medium-density fibreboard.
- ✓ **Phenol-formaldehyde resins (PF)** are used as a furniture adhesive.
- ✓ **Melamine resins**

Urea-formaldehyde resins (UF) are most common used in the MDF industry due to their low cost and fast curing characteristics. However, there are potential problems associated with formaldehyde emissions as formaldehyde is one of the most concerning volatile organic compounds (VOCs). Formaldehyde emissions are greater immediately after wood panel manufacture. Workplaces or storage areas with low air exchange are especially dangerous because of the high concentration of formaldehyde.

Formaldehyde is a known sensitizer and a known carcinogen based on its classification[194]:

- H351: suspected of causing cancer;
- H301: toxic if swallowed:
- H311: toxic in contact with skin;
- H331: toxic if inhaled;
- H314: causes severe skin burns and eye damage;
- H317: may cause an allergic skin reaction.

Formaldehyde emissions during production and end-use are a relevant consequence with negative environmental impacts on ecosystem quality[195]. Therefore, special attention is focused on the reduction of this type of adhesives as well as on their replacement by more environmentally-friendly, natural and safer alternatives such as lignin based materials: lignosulfonates (a lignin co-product of sulfite pulping), organosolved lignin, kraft lignin, flavonoid-based tannins from certain trees starch from renewable sources (chesnut tannin, tara tannin, mimosa tannin or quebracho tannin) or glues derived from animal tissues casein.[196] Certain types of "green" fibreboard consist of bio-based secondary raw materials such as wood chip or sugarcane fibers and the binding agent used is vegetable starch, all natural products containing no added formaldehyde.

A comparative LCA study [197] assesses the relative benefits of alternatives to reduce formaldehyde emissions comparing specified materials – linoleum on MDF (and a variation - linoleum on pine board) - with the MDF lamination process, and also with a new process – the ultra-violet powder coating of MDF. In the LCA, the unit for comparison was 1 m^2 of the finished board. Results showed major impacts for MDF treated with formaldehyde, although LCA does not assess local indoor emissions.

On the other hand, phenol-formaldehyde (PF) resins are more durable and do not emit formaldehyde after cure. However, they have a much higher cost and slower curing rate than UF resins, parameters that currently have been solved by manipulating the fiber temperatures, molecular weight distribution of PF resins and pressing parameters. As a result, the press times for PF-bonded fibreboard can be comparable to those for UF-bonded fibreboard and as advantage the resin content required for PF (less than 5%) is considerably lower than that required for UF. However, the presence of synthetic resins limits the recycling and final disposal of used hardboards[198].

Emission of Volatile Organic Compounds (VOCs) is one of the environmental impacts of furniture products. VOCs are organic chemicals that easily pass to the gas state. They include a wide variety of compounds, including aldehydes, ketones and other light hydrocarbons. Among others, the VOCs are released by paints, adhesives and solvents used in the manufacture of furniture. VOCs are considered as an important factor in the quality of indoor air. Some of them, such as methane, are also greenhouse gases, and others may react to form ozone in the troposphere, which can cause breathing problems. In addition, many VOCs are hazardous for human health. Thus, the reduction of VOC emissions from wood can lead to significant benefits.

6.3.1.4. Paints varnishes and inks

In the assembling of furniture products, the main preparations used in the production process are:

- ✓ Paints and varnishes: these preparations protect the wood and the desired appearance;
- ✓ Inks: these preparations provide the desired color.

Two types of paints can be identified:

- **Water-based paints** include acrylic and latex products.
- **Solvent-based paints** include oil-based, enamel, and alkyd products.

Solvent-based paints, sometimes referred to as "oil-based" or "alkyd" paints, contain a significantly higher level of organic solvents than water-based paints.

The main concern on paints and varnishes is the use of organic solvents, which can evaporate emitting Volatile Organic Compounds. Solvent-based paints can have various combinations of organic solvents including aliphatics, aromatics, alcohols, ketones and white spirit. Specific examples of organic solvents are petroleum distillates, esters and glycol ethers. These compounds (e.g toluene, phenol, formaldehyde, xylene, ethylbenzene, methyl methacrylate, butyl methacrylate, heptane, ethyl acetate, etc.) are mainly volatile and flammable and mostly often classified according to their effect on human health as harmful if inhaled, irritant to eyes, skin and by inhalation.

According to CLP harmonised classifications:

Table 42 CLP harmonised classifications of main concern organic solvents

SUBSTANCE NAME	EC NUMBER	CAS NUMBER	HARMONIZED CLP CLASSIFICATION	
			HAZARD CLASS	HAZARD STATEMENT
Toluene	203-625-9	108-88-3	Flam. Liq. 2 Repr. 2 Asp. Tox. 1 STOT RE 2	H225 H361d H304 H373

SUBSTANCE NAME	EC NUMBER	CAS NUMBER	HARMONIZED CLP CLASSIFICATION	
			HAZARD CLASS	HAZARD STATEMENT
			Skin Irrit. 2 STOT SE 3	H315 H336
Phenol	203-632-7	108-95-2	Muta. 2 Acute Tox. 3 Acute Tox. 3 Acute Tox. 3 STOT RE 2 Skin Corr. 1B	H341 H331 H311 H301 H373 H314
Formaldehyde	200-001-8	50-00-0	Carc. 2 Acute Tox. 3 Acute Tox. 3 Acute Tox. 3 Skin Corr. 1B Skin Sens. 1	H351 H311 H301 H314 H317 H331
Xylene	215-535-7	1330-20-7	Flam. Liq. 3 Acute Tox. 4 Acute Tox. 4 Skin Irrit. 2	H226 H332 H312 H315
Ethylbenzene	202-849-4	100-41-4	Flam. Liq. 2 Acute Tox. 4	H225 H332
Methyl methacrylate	201-297-1	80-62-6	Flam. Liq. 2 STOT SE 3 Skin Irrit. 2 Skin Sens. 1	H225 H335 H315 H317
Butyl methacrylate	202-615-1	97-88-1	Flam. Liq. 3 Eye Irrit. 2 STOT SE 3 Skin Irrit. 2 Skin Sens. 1	H226 H319 H335 H315 H317
Heptane	205-563-8	142-82-5	Flam. Liq. 2 Asp. Tox. 1 Skin Irrit. 2 STOT SE 3 Aquatic Acute 1 Aquatic Chronic 1	H225 H304 H315 H336 H400 H410
Ethyl acetate	205-500-4	141-78-6	Flam. Liq. 2 Eye Irrit. 2 STOT SE 3	H225 H319 H336
1,2-dimethoxyethane; ethylene glycol dimethyl ether (EGDME)	203-794-9	110-71-4	CANDIDATE LIST Toxic for reproduction	
			Flam. Liq. 2 Repr. 1B Acute Tox. 4	H225 H360FD H332

Source: ECHA website

Emission of VOCs may occur during all the life of the furniture, although at lower extent after the manufacturing stage.

The use of paints and varnishes without organic solvents can permit maintaining good indoor air quality helping to improve comfort, welfare and health of building occupants or users of the product, since VOCs are considered as an important factor in the quality of indoor air. Some of the most important effects are short term irritation skin, eyes and respiratory tract, and in the long term, carcinogenic, and harmful to reproductive and nervous systems. Next to persistence and bioaccumulation of these compounds, they contribute to various environmental problems such as ozone formation and the greenhouse effect[98]

Another parameter to be considered is the presence of heavy metals in paints and varnishes, which can be bioacummulative and dangerous for the human health. Nowadays, a wide number of paints and other additives which are metal free exist in the market.

An ink is a liquid or paste that contains pigments or dyes and is used to color a surface. Pigments are granular solids incorporated in the ink to contribute color. Pigments can be classified as either natural or synthetic. Natural pigments include various clays, calcium carbonate, mica, silicas and talcs. Synthetics would include engineered molecules, calcined clays, blanc fixe, precipitated calcium carbonate and synthetic pyrogenic silicas.

Fillers are a special type of pigment that serve to thicken the film, support its structure and increase the volume of the paint. Fillers are usually cheap and inert materials, such as diatomaceous earth, talc, lime, barites, clay, etc.

According to the table below, some pigments are toxic, such as the lead pigments that are used in lead paint:

Table 43 CLP harmonised classifications of main concern pigments

SUBSTANCE NAME	EC NUMBER	CAS NUMBER	HARMONIZED CLP CLASSIFICATION		REASON FOR INCLUSION IN THE AUTHORISATION LIST
			HAZARD CLASS	HAZARD STATEMENT	
Lead chromate	231-846-0	7758-97-6	Carc. 1B Repr. 1A STOT RE 2 Aquatic Acute 1 Aquatic Chronic 1	H350 H360Df H373 H400 H410	Carcinogenic and toxic for reproduction
Lead chromate molybdate sulphate red (C.I. Pigment Red 104)	235-759-9	12656-85-8	Carc. 1B Repr. 1A STOT RE 2 Aquatic Acute 1 Aquatic Chronic 1	H350 H360Df H373H400 H410	Carcinogenic and toxic for reproduction
Lead sulfochromate yellow (C.I. Pigment Yellow 34)	215-693-7	1344-37-2	Carc. 1B Repr. 1A STOT RE 2 Aquatic Acute 1 Aquatic Chronic 1	H350 H360Df H373 H400 H410	Carcinogenic and toxic for reproduction

Source: ECHA website

Pigments and additives based on heavy metals can accumulate in the environment and cause serious damages to ecosystems and human health. One of the largest problems associated with the persistence of heavy metals is the potential for bioaccumulation causing heavier exposure for some organisms than is present in the environment alone. High concentrations of one or more heavy metals in a soil may lead to toxic effects in plants and animals.
Chrome (VI) exists as hydrochromate ($HCrO_4^-$), chromate (CrO_4^{2-}), and dichromate ($Cr_2O_7^{2-}$) ionic species. Chrome (VI) is known to cause severe allergic contact dermatitis in humans and to be able to elicit dermatitis at very low concentrations. Leather goods coming into close prolonged contact with the skin are expected to give rise to the highest exposure of consumer. Examples also include leather cover for seats and furniture, representing a risk for the development of contact allergy to chromium for the consumers.

A range of chrome (VI) compounds are on the SVHC candidate list and Annex XV dossiers have been prepared for more than 15 chrome (VI) compounds. Some examples of pigments containing chrome (VI) are lead chromate, lead sulfochromate yellow (C.I. Pigment Yellow 34) and lead chromate molybdate sulphate red (C.I. Pigment Red 104) all included in the authorization list[22] under REACH regulation meeting the criteria of carcinogenic and toxic for reproduction pursuant to Article 57 (a) and (c) of REACH. The listed potential applications include paints and varnishes, printing inks, vinyl and cellulose acetate plastics, textile printing, leather finishing and paper. Some others chrome (VI) compounds included in the authorisation list of SVHC are: ammonium dichromate, acids generated

[22] Authorization list of Substances of Very High Concern included in Annex XIV of REACH regulation. More information available online at: http://echa.europa.eu/es/addressing-chemicals-of-concern/authorisation/recommendation-for-inclusion-in-the-authorisation-list/authorisation-list

from chromium trioxide and their oligomers (group containing: Chromic acid, Dichromic acid, Oligomers of chromic acid and dichromic acid), chromic trioxide, potassium chromate, potassium dichromate, sodium chromate and sodium dichromate.

Sodium dichromate is an additive based on chrome (VI) included in the authorisation list[23] and used mainly as an ingredient in the production of:

- Metal finishing: aids corrosion resistance, helps clean metal surfaces and promotes paint adhesion
- Pigments: used in the manufacture of inorganic chromate pigment where it produces a range of light stable colors. Also some chromate grades are used as corrosion inhibitors in undercoats and primers.
- Ceramics: used in the preparation of colored glass and ceramic glazes.
- Textiles: used as a mordant for acidic dyes to improve their color-fast properties.
- Leather tanning: dichromate and chromate salts are oxidizing agents used for the tanning of leather.

Anthracene is used as a precursor for dyes (black pigments) and coating materials. Anthracene is included in the candidate list of substances of very high concern meeting the criteria of a PBT substance pursuant to Article 57(d) of REACH.

Creosote is made from coal tar or from wood tar. Coal tar creosote contains polycyclical aromatic hydrocarbons (PAH´s) which are genetically harmful for humans, affect the immune system and reproductive ability and are carcinogenic. Creosote and its compounds from coal tar contain substances classified as toxic and carcinogenic depending on the PAH content. According to table 3.1 of Annex VI of CLP Regulation, creosote (distillate of coal tar with EC number: 232-287-5 and CAS number: 8001-58-9) is classified as : Carc. 1B (H350).

Wood tar creosote contains substances such as cresol, phenols and guaiacol. According to table 3.1 of Annex VI of CLP Regulation, cresol is classified as: Acute Tox 3 and Skin Corr. 1B (H311, H301, H314), phenol is classified as: Muta. 2, Acute Tox. 3, STOT RE 2 and Skin Corr. 1B (H341, H331, H311, H301, H373 and H314). Finally, guaiacol is classified as Acute Tox. 4, Eye Irrit. 2 and Skin Irrit. 2 (H302, H319 and H315).

Legislative authorities have issued restrictions for the use of creosote. Tar oils containing more than 50 mg/Kg benzo(a)pyrene were banned in Europe. Creosote is included in the REACH Restriction list[24] according to its Annex XVII.

Azo dyes are the name of the most important group of synthetic dyes and pigments based on nitrogen representing 60-80% of all organic colorants. They are used widely in substrates such as textile fibres, leather, plastics, papers, hair, mineral oils, waxes, foodstuffs and cosmetics. Some azo dyes may separate under certain conditions to produce carcinogenic and allergenic aromatic amines. The EU Azo colorants Directive 2002/61/EC[25] sets out that Azo dyes which may release one or more of the 22 aromatic amines in detectable concentrations, above 30 ppm in the finished articles or in the dyed components may not be used in textiles and leather articles which may come into direct and prolonged contact with the human skin or oral cavity. The Directive came into force in

[23] For more information, see background document Annex XV for sodium dichromate available online at: http://echa.europa.eu/documents/10162/f766669e-74c2-4a40-847a-5a285af3da2b

[24] List of restrictions according to REACH regulation: http://www.echa.europa.eu/web/guest/addressing-chemicals-of-concern/restrictions/list-of-restrictions/list-of-restrictions-table

[25] Directive 2002/61/EC of the European Parliament and of the council of 19 July 2002 amending for the nineteenth time Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations (azocolourants), more information available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:243:0015:0018:EN:PDF

September 2003. Since Annex XVII of REACH came into force in 2009, the AZO Directive 2002/61/EC has been replaced by REACH regulation. Azo dyes are included in the REACH Restriction List[26].

Cobalt (II) cations are genotoxic under in vitro and in vivo conditions, and have carcinogen, mutagen and reproduction toxicant (CMR) properties. Moreover, the cobalt (II) compounds assess are considered skin and eye irritants and dermal/inhalatory sensitisers. Some of the cobalt compounds that are currently in the candidate list, meeting the criteria of carcinogenic and toxic for reproduction pursuant to Article 57 (a) and (c) of REACH are: cobalt (II) sulphate, cobalt dichloride, cobalt (II) dinitrate, cobalt (II) carbonate and cobalt (II) diacetate.

Cobalt dichloride is used as drying agent in paints (cobalt carboxylates used as drier catalysts in alkyl based paints), pigments (organic textile dyes) and printing inks. In ceramics, frits and glass, cobalt dichloride is used in some applications as a colorant or a decolourant in the production process.

Morevover, aziridine is mainly used in polymerization products as a monomer for polyethyleneimine (polyaziridines), in paper and textile chemicals, adhesives, binders, coating resins, varnishes, lacquers and surfactants. Aziridine, according to harmonized classification of table 3.1 of Annex VI of CLP regulation, is classified as: Flam. Liq. 2, Carc. 1B, Muta. 1B, Acute Tox. 2, Acute Tox. 1, Skin Corr. 1B and Aquatic Chronic 2 (H225, H350, H340, H330, H310, H300, H314 and H411).

6.3.2. Plastic

Figure 38 shows one example product/process which can be regarded as typical for the polymer processing industry:

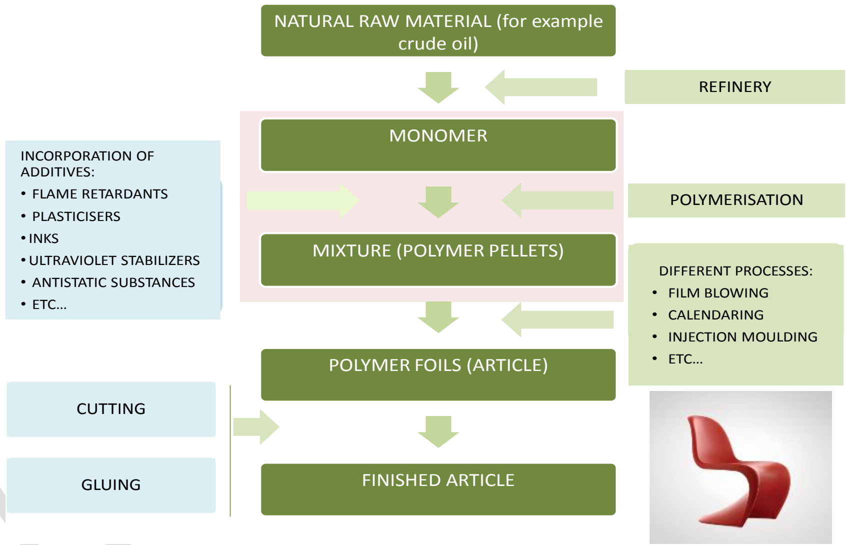


Figure 38. Plastic products

Source: Guidance on requirements for substances in articles[199]

In accordance with the information given at the Plastics Europe website the following substances included in the Candidate list are used in plastic materials[200]:

Table 44. Substances included in the Candidate list used in plastic materials

Name of substance	Articles category	EC number	CAS number	Reason for inclusion in Candidate List
2,4-Dinitrotoluene	Monomer	204-450-0	121-14-2	Carcinogenic (article 57a)
4,4'- Diaminodiphenylmethane (MDA)	Monomer	202-974-4	101-77-9	Carcinogenic (article 57a)
Acrylamide	PA	201-173-7	79-06-1	Carcinogenic and mutagenic (articles

[26] List of restrictions according to REACH regulation: http://www.echa.europa.eu/web/guest/addressing-chemicals-of-concern/restrictions/list-of-restrictions/list-of-restrictions-table

Name of substance	Articles category	EC number	CAS number	Reason for inclusion in Candidate List
	Monomer			57 a and 57 b)
Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins)	PVC	287-476-5	85535-84-8	PBT and vPvB (articles 57 d and 57 e)
Benzyl butyl phthalate (BBP)	PVC PP catalysts	201-622-7	85-68-7	Toxic for reproduction (article 57c)
Bis (2-ethylhexyl)phthalate (DEHP)	PVC PP catalysts	204-211-0	117-81-7	Toxic for reproduction (article 57c)
Chromium trioxide	HDPE catalysts	215-607-8	1333-82-0	CMR
Dibutyl phthalate (DBP)	PVC PP catalysts	201-557-4	84-74-2	Toxic for reproduction (article 57c)
Diisobutyl phthalate	PVC PP catalysts	201-553-2	84-69-5	Toxic for reproduction (article 57c)
Hexabromocyclododecane (HBCDD) and all major diastereoisomers	Flame Retardant EPS, XPS	247-148-4 221-695-9	25637-99-4	PBT (article 57d)
Lead chromate	Pigment	231-846-0	7758-97-6	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Lead chromate molybdate sulphate red (C.I. Pigment Red 104)	Pigment	235-759-9	12656-85-8	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Lead sulfochromate yellow (C.I. Pigment Yellow 34)	Pigment	215-693-7	1344-37-2	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Tris(2-chloroethyl)phosphate	Flame Retardant, plasticiser	204-118-5	115-96-8	Toxic for reproduction (article 57c)

Source: Website of PlasticsEurope

Extra attention should be given to polycarbonates due to the possible presence of bisphenol A. According to table 3.1 of Annex VI of CLP Regulation, bisphenol A (4,4'-isopropylidenediphenol EC 201-245-8, CAS 80-05-7) is classified as: Repr.2, STOT SE 3, Eye Dam.1 Skin Sens. 1 (H361f, H335, H318, H317).

Bisphenol A is also used in paints, varnishes, glues (binding agents and hardeners), polyol in the production of polyurethane and various plastics. Bisphenol A can be released to the environment from the production process causing endocrine effects in both fish and snails. The main source of terrestrial exposure is the spread of sludge from sewage treatment plants. In humans there is not a direct exposure, although bisphenol A is present in many consumer products, especially in plastics made of polycarbonates.

Phthalates are typically used as plasticizers in PVC. Phthalates classified as toxic for reproduction (Article 57 (c) of REACH) such as:

- Dibutyl phthalate (DBP), bis (2-ethylhexyl)phthalate (DEHP), benzyl butyl phthalate (BBP) and Diisobutyl phthalate (DIBP) are included in Annex XIV of REACH Regulation according to substances subjected to authorization.
- Dipentyl phthalate (DPP), N-pentyl-isopentylphthalate, diisopentylphthalate (DIPP) and Bis(2-methoxyethyl) phthalate are included in the candidate list of SVHC.
- Diisononyl phthalate (DINP), diisodecyl phthalate (DIDP) and di-n-octyl phthalate (DOP or DnOP) are included in Annex XVII of the REACH regulation according to substances subjected to restriction. According to this annex, toys and childcare articles containing these phthalates in a concentration greater than 0.1% by weight of the plasticized material shall not be placed on the market.

Polyvinyl chloride, commonly known as PVC, is the third-most widely produced plastic, after polyethylene and polypropylene. It can be made more flexible by the addition of plasticizers, the most widely used being phthalates. PVC is produced by polymerization of the monomer vinyl chloride (chloroethene abbreviated as VCM) classified as Carc. 1A according harmonized CLP classification and contains 57% of chlorine. The content of chlorine may contribute to increased development of dioxins in the waste gas from the waste incineration plant. Dioxins are commonly regarded as highly toxic compounds that are environmental pollutants and persistent organic pollutants (POPs). Therefore, PVC is not suited for combustion; however the problem is that PVC waste may end in the rubbish deposited by consumers, which may be finally combusted.

6.3.3. Metal

Primary metals have higher impacts than plastics due to higher demand of energy and raw materials consumption; they have also some advantages, e.g. metals can be recycled more easily than plastic packaging.

Regarding hazardous substances, sodium dichromate is a substance included in the candidate list[27] and used mainly as an ingredient in the production of:

- Metal finishing: aids corrosion resistance, helps clean metal surfaces and promotes paint adhesion
- Pigments: used in the manufacture of inorganic chromate pigment where it produces a range of light stable colors. Also some chromate grades are used as corrosion inhibitors in undercoats and primers.
- Ceramics: used in the preparation of colored glass and ceramic glazes.
- Textiles: used as a mordant for acidic dyes to improve their color-fast properties.
- Leather tanning: dichromate and chromate salts are oxidizing agents used for the tanning of leather.

6.3.4. Padding materials

4,4-Diaminodiphenylmethane (MDA) is used primarily for making polyurethane foams in upholstered furniture. Lower quantities are used as hardeners in epoxy resins and adhesives, as well as in the production of high-performance polymers. MDA is a suspected carcinogen included in the Authorisation list of substances of very high concern.

Moreover, methylene chloride is an organic compound widely used as a solvent and blowing agent for polyurethane foams. According to table 3.1 of Annex VI of CLP regulation, methylene chloride (EC number 200-838-9, CAS number 75-09-2) is classified as Carc.2 (H351).

Blowing agents can be used in the production of PUR foams for upholstery furniture. The use of many chlorine-containing blowing agents, such as trichlorofluoromethane (CFC-11), was restricted by the Montreal Protocol on Substances that Deplete the Ozone Layer in the early 1990s, due to the negative impact on the ozone layer.

HFCs replaced chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), that are phased out under the Montreal Protocol. HFCs pose no harm to the ozone layer because, unlike CFCs and HCFCs, they do not contain chlorine that depletes the ozone layer. However, they are greenhouse gases with an extremely high global warming potential and included in the Kyoto Protocol due to the recognition of halocarbon contributions to climate change.

Perfluoroalkyl acids are used in surface treatments due to their excellent surface properties and water and oil repelling properties in upholstery products (textiles and leather). Pentadecafluorooctanoic acid (PFOA) and its ammonium salt, ammonium pentadecafluorooctanoate (APFO), are included in the candidate list of SVHC meeting the criteria of toxic for reproduction and PBT pursuant to Articles 57 (c) and (d) of REACH.

[27] For more information, see background document Annex XV for sodium dichromate available online at: http://echa.europa.eu/documents/10162/f766669e-74c2-4a40-847a-5a285af3da2b

The compound is also used in electric wires due to high electrical insulation properties and high ability to withstand corrosion, fire fighting foam and outdoor clothing. As a salt, it is used as an emulsifier for the emulsion polymerization of fluoropolymers such as polytetrafluoroethylene (PTFE or Teflon), polyvinylidene fluoride and fluoroelastomers.

The stability of PFOA is desired industrially, but a cause of concern environmentally. PFOA is resistant to degradation by natural processes such as metabolism, hydrolysis, photolysis, or biodegradation making it persist indefinitely in the environment. Furthermore, they are toxic for reproduction.

6.3.5.Glass

Diarsenic pentaoxide and diarsenic trioxide are used in glass products and included in the authorisation list meeting the criteria of carcinogenic pursuant to Article 57 (a) of REACH.

6.3.6. Packaging materials

Different materials are used for packaging of furniture products under study. Packaging is usually made of different kinds of plastic and paper or cardboard:

- **Plastic packaging:** Impacts come mainly from energy use in the manufacturing stage and the presence of hazardous substances according to section 6.3.2 regarding plastic materials.
- **Paper/cardboard packaging**: Chlorine bleaching process produces highly toxic and persistent organochlorines such as dioxins. Dioxins are recognized as persistent environmental pollutants, regulated internationally by the Stockholm Convention on Persistent Organic Pollutants[201] and chlorine gas is classified as H400 (very toxic to aquatic life), H315 (causes skin irritation), H319 (causes serious eye irritation), H331 (toxic if inhaled) and H335 (may cause respiratory irritation).

6.3.7.Nanomaterials

In accordance with the report "Nanomaterials in consumer products, availability on the European market and adequacy of the regulatory framework"[202] some materials intentionally manufactured for use as nanoforms are used in furniture products.

Definition of nanomaterials

In general the term ‘nanomaterial’ usually refers to ‘materials with external dimensions, or an internal structure, measured in nanometres that exhibit additional or different properties and behaviour compared with coarser materials with the same chemical composition[203].

The European Commission[204] defined recently the term nanomaterials as: *a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm.*

In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50 % may be replaced by a threshold between 1 and 50 %.

By derogation from the above, fullerenes, graphene flakes and single wall carbon nanotubes with one or more external dimensions below 1 nm should be considered as nanomaterials.

The purpose of the definition is to provide unambiguous criteria to identify materials for which specific considerations in their risk assessment must be taken into account. The risks posed by the nanomaterials to the environment and human health should be assessed using the existing risk assessment approach in the EU. Only the results of the risk assessment will determine whether the nanomaterial is hazardous. However, based on the conclusions from the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)[205], there is still scientific uncertainty about the safety of nanomaterials in many aspects.

In general, nanomaterials can be grouped in three categories[206]:

a) Materials that are nanostructured in the bulk of the product

- One-phase materials (solid product),
- Multi-phase materials (solid packaging with a liquid product inside).

b) Materials that have nanostructure on the product surface

- One-phase materials structured on the nanoscale at the surface,
- Nanoscale thick unpatterned films on a substrate of different material,
- Patterned films of nanoscale thickness or a surface having nanoscale dimensions.

c) As particles

- Surface-bound nanomaterials,
- Nanoparticles suspended in liquids,
- Nanoparticles suspended in solids,
- Free airborne particles.

On the basis of available information, furniture can be assigned to the second category: materials that have nanostructure on the product surface.

It is important to mention that the nanomaterials, when used in a product, could be differentiated based on their physical state as embedded to substrate ones and free nanomaterials. This difference is important when exposure to consumers is considered. The consumers are exposed to nano in case of free nanomaterials whereas they are not or less exposed in case of embedded nano-ingredients[207].

The location of the nanomaterial is related with the following exposure categories:

a) **Expected to cause exposure**: when consumers are in direct contact with the products (relevant e.g. for “nanoparticles in liquids” and “airborne particles”).

b) **May cause exposure**: Although the nanoparticles in the product are not considered to be released intentionally, they may be released from the product because of wear and tear, e.g. “surface bound nanoparticles”.

c) **No expected exposure to the consumer**: Negligible exposure is expected when nanoparticles are encapsulated in the product.

However, even embedded forms may become free, for example by manipulations or erosion. Therefore, it is critically important to take into account a life cycle perspective. One prominent example may be carbon nanotubes, which are mainly embedded in composites and, therefore, exposure during manufacturing and potentially during subsequent manipulation such as recycling may be the principal concern.

Concerns related to nanomaterials

In a nutshell the concerns related to nanomaterials are linked to the so called "nanomaterials paradox", i.e. desired effects versus unexpected hazardous impact on health. The very same properties that are desirable and potentially useful from a technological perspective, such as the high degree of surface reactivity, are also the properties that may give rise to unexpected and undesired effects. It can be noted, however, that the nanomaterials paradox is not unique to nanomaterials as this principle applies also to pharmaceuticals.

According to the opinion of the Scientific Committee on Consumer Products (SCCP)[208], there is insufficient knowledge on: hazard identification, exposure, uptake, absorption and transport across membranes, accumulation in secondary target organs, possible health effects, translocation of nanoparticles via the placenta to the foetus and in vitro and in vivo test methods validated or optimized for nanomaterials[209]. The current methods used in REACH to assess the toxicological and ecotoxicological risk may not be adequate to evaluate the risks related to nanomaterials. Consequently, there is a lack of knowledge regarding the damage nanomaterials may cause.

Legislative framework

REACH is the legislation applicable to the manufacturer and/or importer, placing on the market and useing substances on their own, in preparations or in articles. Currently, nanomaterials are covered by the definition of a "substance" under REACH, although there is no explicit reference to nanomaterials and the same REACH provisions apply to all chemical substances. REACH places responsibility on industry to manage the risks that chemicals may pose to human health and environment, as well as to provide safety information that should be passed down the supply chain.

Until recently ECHA[210] has not given any specific guidance concerning nanomaterials. In 2009 the Commission launched a REACH Implementation Project on Nanomaterials (RIPoN) to provide advice on key aspects of REACH with regard to nanomaterials concerning Information Requirements (RIPoN 2) and Chemical Safety Assessment (RIPoN 3)[211]. Based on the results, on 30 April 2012 ECHA published three new appendices updating Chapters R. 7a, R. 7b and R. 7C of the Guidance on Information Requirements and Chemical Safety Assessment. These three new appendices are recommendations for registering nanomaterials and the adequacy of test methods. Consequently at the end of this year and in advance of the next registration deadline, i.e. 30 May 2013, ECHA plans to update the guidance for registration of substances in nanoform and proposal for additional specific for nanomaterials information requirements. A third report of the RIPoN project relates to Substance Identity but it was not possible to reach consensus amongst the expert on the recommendations. Some adjustments are still needed in REACH legislation to assess and control the risks of nanomaterials.

As a result, manufactured nanomaterials are expected to undergo similar tests like other chemicals. Therefore, assuming that they are not classified with the restricted risk phrases, they will then fulfil the requirements of the new Ecolabel criterion on the use of hazardous substances (the criterion which is based on article 6.6 and 6.7 of Ecolabel Regulation 66/2012) and would be allowed.

Apart from the previously mentioned issues, works are being conducted with regard to the evaluation of the legislative framework for controlling and appropriate disposal of nanomaterials at the end of life phase. A recent study of MILIEU and Amec[212] examined the legislative framework for controlling nanomaterial release. It was noted that limitations in both exposure and hazard data for specific nanomaterials cause difficulties in assessment of the potential risks which nanomaterials can cause. The precautionary principle for the control of nanomaterials was emphasized by the authors. Another study[213] suggests that more data collection and research should be done in the area of waste disposal for nanotechnology to ensure that appropriate means of control are in place.

It can be seen that at present, there is inadequate information on risks associated to nanomaterials and in order to better assess their safety new test methodologies taking into account specific characteristic of nanomaterials are needed, also the lack of scientific evidence regarding their use and related impacts is an important factor to consider.

7.APPENDICES

7.1.APPENDIX I. Market data for production, exports and imports.

Table A.I. Production data of furniture (in €)

	PRODVAL (€)	
	2010	2011
France	4.716.838.298	4.915.473.602
Netherlands	1.402.092.000	1.431.376.000
Germany	10.345.501.190	10.164.745.495
Italy	12.062.889.000	13.412.765.000
UK	5.535.974.076	5.232.161.126
Ireland	961.797.000	228.299.000
Denmark	1.335.797.805	1.267.949.292
Greece	175.761.787	149.496.650
Portugal	852.258.042	778.358.998
Spain	3.795.000.428	3.289.956.293
Belgium	1.023.453.921	1.026.023.991
Luxemburg	0	0
Sweden	529.791.346	1.250.360.583
Finland	675.539.909	670.404.799
Austria	668.543.600	669.705.100
Malta	0	0
Estonia	226.879.707	253.714.844
Latvia	86.855.233	92.202.573
Lithuania	453.410.737	620.741.543
Poland	3.633.020.328	3.888.437.386
Czech Republic	537.609.555	545.908.460
Slovakia	340.061.346	385.096.514
Hungary	298.765.551	304.999.130
Romania	963.897.200	1.024.977.689
Bulgaria	234.507.108	238.430.411
Slovenia	229.611.702	199.987.074
Cyprus	0	0

Table A.II. Production data of furniture (in number of units)[28]

	PRODQNT (units)	
	2010	2011
France	34.955.610	35.468.883
Netherlands	2.439.125	2.084.207
Germany	81.275.401	79.823.900
Italy	150.565.590	158.737.582
UK	53.826.821	49.143.690
Ireland	6.877.773	6.164.572
Denmark	16.431.241	15.065.736
Greece	3.885.631	3.190.590
Portugal	12.516.754	12.913.893
Spain	39.722.273	35.416.871
Belgium	5.159.283	5.325.895
Luxemburg	0	0
Sweden	5.762.314	20.904.804
Finland	7.054.190	6.268.997
Austria	2.514.247	2.480.093
Malta	0	0
Estonia	3.170.304	3.959.247
Latvia	484.100	466.283
Lithuania	11.941.526	14.791.712
Poland	47.853.966	53.646.000
Czech Republic	4.768.755	4.175.613
Slovakia	3.820.613	4.260.251
Hungary	2.207.000	2.243.547
Romania	22.160.039	20.701.360
Bulgaria	5.163.312	4.992.859
Slovenia	2.259.957	1.903.619
Cyprus	0	0

[28] excluding metal furniture, classified as NACE code 31091100, which is expressed in kilograms

Table A.III. Production of metal furniture classified as NACE code 31091100 (in kg)

	PRODQNT (kg)	
	2010	2011
France	108.054.878	118.197.126
Netherlands		
Germany	0	
Italy	56.668.754	57.444.726
UK	26.274.956	29.093.385
Ireland	1.142.538	3.092.167
Denmark	9.106.281	7.907.957
Greece	751.115	730.912
Portugal	5.961.118	4.287.948
Spain	92.970.340	82.002.701
Belgium	16.173.743	19.679.351
Luxemburg	0	0
Sweden		
Finland	1.989.097	
Austria	19.968.688	16.918.462
Malta	0	0
Estonia	201.166.500	84.462.100
Latvia		
Lithuania	853.997	4.996.627
Poland	52.226.604	67.211.973
Czech Republic	65.256.000	84.350.000
Slovakia	11.641.269	13.797.090
Hungary	4.279.000	23.028.000
Romania	3.324.359	2.644.447
Bulgaria	4.678.607	4.567.190
Slovenia	11.245.958	10.562.088
Cyprus	0	0

Table B.I. Intra and Extra EU-27 furniture exports (in €)

	EXPVAL (€)	
	2010	2011
France	1.202.749.040	1.179.137.120
Netherlands	1.040.332.860	1.026.524.120
Germany	5.297.713.100	5.873.865.540
Italy	5.776.015.180	5.894.884.550
UK	673.720.730	729.946.270
Ireland	66.062.990	67.363.720
Denmark	1.221.442.210	1.221.709.550
Greece	37.148.630	40.194.670
Portugal	497.404.140	541.218.750
Spain	928.074.560	1.029.863.680
Belgium	1.035.845.720	1.026.426.150
Luxemburg	15.301.410	10.619.700
Sweden	1.185.091.420	1.300.438.410
Finland	88.098.610	87.621.750
Austria	660.412.430	782.844.800
Malta	1.808.800	778.570
Estonia	196.028.870	224.021.790
Latvia	107.117.780	113.863.910
Lithuania	533.956.820	670.990.950
Poland	3.692.596.900	4.019.867.110
Czech Republic	398.951.260	430.490.540
Slovakia	431.263.860	451.841.590
Hungary	215.655.570	224.027.850
Romania	759.349.460	861.481.450
Bulgaria	125.635.250	141.398.590
Slovenia	280.632.520	255.981.970
Cyprus	6.753.550	3.476.240

Table C.I. Intra and Extra EU-27 furniture imports (in €)

	IMPVAL (€)	
	2010	2011
France	4.372.601.170	4.262.024.910
Netherlands	1.978.761.030	1.902.004.210
Germany	5.245.580.280	5.449.376.760
Italy	1.251.742.810	1.265.842.810
UK	3.758.522.780	3.385.328.080
Ireland	250.669.750	220.442.370
Denmark	862.980.600	832.355.010
Greece	393.122.210	283.653.540
Portugal	329.809.650	287.964.430
Spain	1.433.390.570	1.269.915.280
Belgium	1.656.534.610	1.693.221.680
Luxemburg	183.297.680	192.898.680
Sweden	983.979.980	1.053.169.600
Finland	319.387.270	333.053.810
Austria	1.448.073.180	1.634.610.710
Malta	40.586.080	39.037.850
Estonia	47.429.270	55.588.620
Latvia	66.800.140	72.367.280
Lithuania	50.684.080	64.447.750
Poland	433.447.290	452.250.090
Czech Republic	415.635.040	431.063.210
Slovakia	189.387.630	221.603.370
Hungary	139.697.680	148.159.940
Romania	203.271.310	224.791.690
Bulgaria	98.583.060	91.593.010
Slovenia	147.139.130	140.680.600
Cyprus	112.645.640	96.993.870

7.2.APPENDIX II. Full LCA screening data and tables

Table 45. List of Product Category Rules for furniture

REFERENCE	SCHEME	SCOPE
THE INTERNATIONAL EPD®SYSTEM. PCR BASIC MODULE CPC Division 38 FURNITURE; OTHER TRANSPORTABLE GOODS VERSION 1.1 DATED 2009-08-06 *Basic module 38: Furniture, other transportable goods not elsewhere classified*[214]	THE INTERNATIONAL EPD®SYSTEM (ENVIRONDEC)	product group includes furniture, jewellery, musical instruments, sports goods, games, toys, fairground amusements, prefabricated buildings and other manufactured articles.
THE INTERNATIONAL EPD®SYSTEM. Other Furniture VERSION 1.0 2012-05-08 *Product group UN CPC Class 38140 "Other furniture no elsewhere classified."*[215]	THE INTERNATIONAL EPD®SYSTEM (ENVIRONDEC)	The product category includes all other furniture goods that are not specified in the CPC classes 3811 (Seats); 3812 (Other furniture, of a kind used in offices); 3813 (Other wooden furniture, of a kind used in the kitchen); 3815 (Mattress supports and mattresses); 3816 (Parts of furniture). Examples of other furniture goods (Class 3814), are tables, wardrobes etc., unless not primary used in offices (Class 3812) or in the kitchen (Class 3813).
THE INTERNATIONAL EPD®SYSTEM. UN CPC Class 3811: Seats PCR 2009:02 Version 1.0 *Product group UN CPC Class 3811 Seats*[216]	THE INTERNATIONAL EPD®SYSTEM (ENVIRONDEC)	Seating solutions
THE INTERNATIONAL EPD®SYSTEM. CPC 38160 PARTS OF FURNITURE PCR 2009:01 VERSION 1.1 2010-02-25 *Product group UN CPC Class 38160 "Parts of furniture"*[217]	THE INTERNATIONAL EPD®SYSTEM (ENVIRONDEC)	The product category includes parts and component of furniture for offices, kitchen, bedroom and other functions.
Product Category Rules (PCR) for System Cabinet PCR 2011:1.0 JIA WONG ENTERPRISE, LTD. (Taiwan). Version 1.0 2011-03-31[218]	JIA WONG ENTERPRISE	System Cabinets
Institut Bauen und Umwelt e.V. (IBU). PCR document "Wood-based materials", year 2009-11.[219]	Institut Bauen und Umwelt e.V. (IBU).	- chipboard (P1 – P7) - MDF / HDF (dry method) - fibreboard (wet method) - OSB (1-4) - plywood - special wood materials (e.g. decorative synthetic-resincoated wooden materials)
Institut Bauen und Umwelt e.V. (IBU). PCR document "Laminates", base year 2009.[220]	Institut Bauen und Umwelt e.V. (IBU).	
Norwegian EPD Foundation. PRODUCT CATEGORY RULES (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group Seating solution NPCR 003 October 2013[221]	Norwegian EPD Foundation.	products that provide the function of seating
Norwegian EPD Foundation. Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group Sleeping solution[222]	Norwegian EPD Foundation.	products that provide the function of a sleeping solution
Norwegian EPD Foundation. PRODUCT-CATEGORY RULES (PCR) for preparing an	Norwegian EPD	products that provide a function as

environmental Product Declaration (EPD) for Product Group Table NPCR 005 Revised version.[223]	Foundation.	tables
PRODUCT-CATEGORY RULES (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group Plate furniture NPCR 021. April 2012[224]	Norwegian EPD Foundation.	plate furniture, a subcategory of furniture. The rules apply to products that provide the function of tables, cabinets, cabinet frames, shelves, office-desks, counters, dressers or similar.
Product Category Rules (PCR) for preparing an environmental Product Declaration (EPD) for Product Group Upholstery textiles Last revised: 17th November 2006[225]	Norwegian EPD Foundation.	upholstery textiles, a subcategory of furniture.
BP X30-323-4 Meubles en bois. Principes généraux pour l'affichage environnemental des produits de grande consommation - Partie 4 : méthodologie d'évaluation des impacts environnementaux des meubles en bois[226]	France. Grenelle Law.	Wood furniture

Table 46. List and characteristics of EPDs

Product group	Product / Company / Model	Scheme	Use	Observations
CHAIRS (29)	Chair. Company RH. Model Ambio	THE INTERNATIONAL EPD®SYSTEM.	Office	
	Chair. Company RH. Model active	THE INTERNATIONAL EPD®SYSTEM.	Office	
	Chair . Company RH . Model extend	THE INTERNATIONAL EPD®SYSTEM.	Office	
	Chair . Company RH. Model Logic	THE INTERNATIONAL EPD®SYSTEM.	Office	
	Chair base Aluminium. Company Donati	THE INTERNATIONAL EPD®SYSTEM.	Office	
	Chair base mechanism. Company Donati	THE INTERNATIONAL EPD®SYSTEM.	Office	
	Chair Green's SITLAND	THE INTERNATIONAL EPD®SYSTEM.	Domestic	
	Chair. Company ARPER. Model Team	THE INTERNATIONAL EPD®SYSTEM.	Domestic	6 EPDs models
	Chair Company ARPER. Model Babar	Norwegian EPD Foundation.	Domestic	
	Chair .Company ARPER. Model stool	Norwegian EPD Foundation.	Domestic	
	Chair. Company ARPER. Model Catife	Norwegian EPD Foundation.	Domestic	4 EPDs models
	Chair. Company BackApp. Model Mobil. NEPD 167E	Norwegian EPD Foundation.	Office	2 EPDs models
	Chair. Company HÅG H03 320 Office Chair, NEPD nr 034N og 034E	Norwegian EPD Foundation.	Office	2 EPDs models
	Chair. Company HÅG Capisco 8106 Office Chair,	Norwegian EPD Foundation.	Office	
	Chair. Company HÅG. Model	Norwegian EPD	Office	

	H09 Inspiration 9230 Office Chair,	Foundation.		
	Chair. Company HÅG. Model H04 Communication 4470 Conference / Visitor Chair,	Norwegian EPD Foundation.	Office	2 EPDs models
	Chair. Company HÅG. Model Conventio 9510 Conference / Visitor Chair,	Norwegian EPD Foundation.	Office	
	Chair. Company HÅG. Model Futu Office Chair	Norwegian EPD Foundation.	Office	
	Chair. Company HÅG. Model Sideways 9732 Conference / Visitor Chair,	Norwegian EPD Foundation.	Office	
	Chair. Company HÅG. Model Conventio Wing 9811, Conference / Visitor Chair,	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Splice 10,	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Teamspirit 2,	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. ModelSavo stool,	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Savo Studio 32	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Savo EOS HL	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Savo Ikon 3 LN	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Savo XO ML	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model Savo S3 LN	Norwegian EPD Foundation.	Office	
	Chair. Company EFG. Model *Savo Studio 22*	Norwegian EPD Foundation.	Office	
Tables (1)	Table. Company ARPER. Model GINGER	THE INTERNATIONAL EPD®SYSTEM.	Domestic	16 EPDs models
Laminates and boards (5)	EGGER Laminates Flex, MED, Micro	Institute Construction and Environment (IBU)	Domestic	
	EGGER EUROSPAN® Raw Chipboard EURODEKOR® Melamine faced Chipboard	Institute Construction and Environment (IBU)	Domestic	
	EGGER EUROLIGHT® Raw and Laminated Lightweight Board	Institute Construction and Environment (IBU)	Domestic	
	Glunz AG TOPAN® MDF AGEPAN® Wood Fibreboards	Institute Construction and Environment (IBU)	Domestic	
	Decorative High-Pressure Laminates International Committee of the Decorative Laminates Industry (ICDLI)	Institute Construction and Environment (IBU)	Domestic	

Table 47. LCA and environmental studies gathered

Category		Number/type of papers	References
Furniture made of wood	Panels	1 report laminate wood	Cho, S., Huang, J. An Investigation into Sustainable Building Materials – Laminate Wood. 2010
		1 paper hardboard	González-García, S., Feijoo, G., Heathcote, C., Kandelbauer, A., Moreira, T. Environmental assessment of green hardboard production coupled with a laccase activated syste. Journal of Cleaner Production 19 (2011) 445e453
		1 report MDF recycling	Mitchell, A., Stevens, G. Life Cycle Assessment of Closed Loop MDF Recycling: Microrelease Trial. 2009
		1 paper MDF	Rivela B, Moreira MT, Feijoo G (2007): Life Cycle Inventory of Medium Density Fibreboard. Int J LCA 12 (3) 143–150
		1 report MDF	Wilson, J.B., Medium Density Fiberboard (MDF): A Life-Cycle Inventory of Manufacturing Panels from Resource through Product, 2008
	Wood products	1 paper childhood set	González-García, S. , Raúl García Lozano, R., Moreira T., Gabarrell, X., Rieradevall, J., Feijoo, G., Murphy, R.J. Eco-innovation of a wooden childhood furniture set: An example of environmental solutions in the wood sector. Science of the Total Environment 426 (2012) 318–326
		1 report desk (Italy)	IGEAM - Unione Industriali Pordenone. Scrivania - MArtex LCA – VALUTAZIONE DEL CICLO DI VITA, 2010
		1 report Workplace: (Italy)	IGEAM - Unione Industriali Pordenone. Postazione di Lavoro Alea LCA – VALUTAZIONE DEL CICLO DI VITA, 2010
		1 report wardrobe (Italy)	IGEAM - Unione Industriali Pordenone. Armadio Mascagni – Dall'Agnese LCA – VALUTAZIONE DEL CICLO DI VITA, 2010
		1 report wardrobe (Italy)	IGEAM - Unione Industriali Pordenone. Armadio – Martex LCA – VALUTAZIONE DEL CICLO DI VITA, 2010
		1 report kitchen (Italy)	IGEAM - Unione Industriali Pordenone. Cucina Samoa – Copat LCA – VALUTAZIONE DEL CICLO DI VITA
		1 report door (Italy)	IGEAM - Unione Industriali Pordenone. Ante – Acop LCA – VALUTAZIONE DEL CICLO DI VITA
		1 report. School desk	UNEP SETAC. Life Cycle Assessment. A product-oriented method for sustainability analysisTraining Manual. 2008
	Forestry	4 papers of forestry in Ghana	Eshun, J.F., Potting, J. , Leemans, R. LCA of the timber sector in Ghana: preliminary life cycle impact assessment (LCIA). Int J Life Cycle Assess (2011) 16:625–638 Eshun, J.F., Potting, J. , Leemans, R. Inventory analysis of the timber industry in Ghana. Int J Life Cycle Assess DOI 10.1007/s11367-010-0207-0 Eshun, J.F., Potting, J. , Leemans, R. Wood waste minimization in the timber sector of Ghana: a systems approach to reduce environmental impact. JCP, 2012
		1 report on forestry	European forest institute. Energy, carbon and other material flows in the Life Cycle Assessment of Forestry and forest products. 2001
		1 report forestry	LCA a challenge for forestry and forest products. 1995
		1 report of forestry in Australia	Tucker, S.N. , Tharumarajah, A.,May, B. , England, J., , K. Paul, K., Hall, M., Mitchell, P., Rouwette, R., Seo, S., Syme, M. Life Cycle Inventory of Australian Forestry and Wood Products. 2009
	Preservatives	1 report / paper	Bolin, C.A., Smith, S.T. Life Cycle Assessment Procedures and Findings for ACQ-Treated Lumber

	General	1 report (Grenelle Law, France)	ADEME (Agence de l'Envrinnement et de la Maltreise de l'Energie). Rapport d'étude PROPILAE – V1 – 2010.
		1 report wood applications	Vogtländer, J:G:, Life Cycle Assessment of Accoya® Wood and its application,
Furniture made of metals		2 reports / papers	Conway, C.C., Steelcase Green Product Development: An Early Stage Life Cycle Analysis Tool and Methodology . 2008
			Dietz, B.A., Life cycle assessment of office furniture products, 2005
Furniture made of mixed materials		8 reports / papers	Center for Sustainable Systems. University of Michigan. Life-Cycle Assessment of Office Furniture Products. Final report on the study of three Steelcase office furniture. 2006
			Forest & Wood Products Research & Development Corporation. Review of the Environmental Impact of Wood Compared with Alternative Products Used in the Production of Furniture. 2003
			Indian Centre for Plastics in the Environment (ICPE). Summary report for life cycle assessment of furniture
			Kebbouche, Z., Tairi, A., Cherifi, A., Impact study and valorization of waste of metal furniture by the LCA method.
			Russell, S.N., Allwood, J.M. *Environmental evaluation of localising production as a strategy for sustainable development: a case study of two consumer goods in Jamaica.* Journal of Cleaner Production 16 (2008) 1327e1338
			Sahni, S. , Boustani, A.,Gutowski, T.,, Graves, S. Furniture Remanufacturing and Energy Savings. 2010
			Suttie, E., Briefing note for Forestry Commission An update on Wood Plastic Composites (WPC). 2007
			Université M'Hamed Bougara Bourmerdès.Impact study and valorisation of waste of metal furniture by LCA method
		5 reports /papers chairs	DONATI environmental awareness
			Gamage, G. B. , Boyle, C. , McLaren S.J., McLaren, J. Life cycle assessment of commercial furniture: a case study of Formway LIFE chair. Int J Life Cycle Assess (2008) 13:401–411
			Michelsen, O., Fet, A.M., Dahlsrud, A. Eco-efficiency in extended supply chains: A case study of furniture production. Journal of Environmental Management 79 (2006) 290–297
			Michelsen, O. Eco-efficiency in redesigned extended supply chains; furniture as an example. 2007
			Michelsen, O. Investigation of relationships in a supply chain in order to improve environmental performance. 2007
End of life (including reuse)		11 reports / papers	Critchlow, J. End of life furniture sustainability. 2010
			Curran, A. , IWilliams, I.B. The role of furniture and appliance re-use organisations in England and Wales. 2009
			Hong Ren, H., Thesis, M. Plastic Waste Recycling and Greenhouse Gas Reduction Greenhouse. 2012
			Hopewell, J., Dvorak, R.,Kosior, E. Plastics recycling: challenges and opportunities. Phil. Trans. R. Soc. B 2009 364, 2115-2126
			JUNGMEIERG , MERL A , McDARBY F , GALLIS C, HOHENTHAL C, PETERSEN AK, SPANOS K. End of Use and

		End of Life Aspects in LCA of Wood Products – Selection of Waste Management Options and LCA Integration
		Rivelaa, B., Moreira, T., Muñoz, I., Joan Rieradevall, J., Feijoo G. Life cycle assessment of wood wastes: A case study of ephemeral architecture. 2005
		Werner, F., Althaus, H-J., Richter, K. , Scholz, R.W. Post-Consumer Waste Wood in Attributive Product LCA. 2007
		WRAP. Benefits of Reuse Case Study: Domestic Furniture. 2011
		WRAP. Benefits of Reuse Case Study: Office Furniture. 2011
		WRAP. A methodology for quantifying the environmental and economic impacts of reuse
		Werner, F. Reecycling of used wood - inclusion of end-of-life options in LCA.
Temporary carbon storage	2 reports / papers	Brandão, M., Levasseur, A. Assessing Temporary Carbon Storage in Life Cycle Assessment and Carbon Footprinting. 2010
		Perez-Garcia, J., Lippke, B., Comnick, J., Manriquez, C. An assessment of carbon pools, storage, and wood products market substitution using Life-Cycle analysis results.
Hot-spots identification	6 reports / papers	Andriola, L., Buonamici, R., Caropreso, G., Luciani, R., Masoni, P., Roman, R. Advances in Life Cycle Assessment and Environmental Management Systems: An Integrated-Approach Case Study for the Wood-Furniture Industry
		Chaves, L.I. Design for sustainability: A methodological approach for the introduction of environmental requirements in the furniture sector. 2008
		Liedtke, C., Rohn, H., Kuhndt, M.,Nickel, R. Applying Material Flow Accounting: Ecoauditing and Resource Management at the Kambium Furniture Workshop
		Pitcher, M. LCA IN FURNITURE RATING TOOLS - A USER S VIEW
		WRAP. A methodology for quantifying the environmental and economic impacts of reuse
		Werner, F. Recycling of used wood - inclusion of end-of-life options in LCA.
Health issues/Chemicals	3 reports / papers	Andersson, P., Simonson, M. Stripple, H. Fire safety of upholstered furniture, A Life-Cycle Assessment – Summary Report. 2003
		Askham, C.,Hanssen, O.J., Gade, A.L. ,Nereng, G., Aaser, C.P., Christensen, P. Strategy tool trial for office furniture. Int J Life Cycle Assess (2012) 17:666–677 DOI 10.1007/s11367-012-0406-y
		Pitcher, M. LCA Treatment of Human Health exemplified by formaldehyde within the furniture industry. 2005
General guidelines	1 guide with LCA approach	IHOBE. Sectorial Guide of Ecodesign. Furniture (Guías sectoriales de ecodiseño. Mobiliario). 2010.

Table 48. Cut-off and scoring criteria for LCA studies evaluation

#	Item	Cut-off (minimal requirements)	Scoring
1	**title**	-	-
2	**authors**	-	-
3	**reference and year**	-	-
4	**type of study (e.g. attributional/consequential LCA according to ISO 14040, PCRs, PAS 2050:2011, PEF)**	QUALITY OF SCOPE: ✓ Functional unit properly defined and relevant for this revision. ✓ Scope coherent for the goal of the study ✓ Assumptions of the study shall respect ISO 14040 standard.	S_{SCOPE} 5 = coherent LCA for broad group of products of interest. Scope from cradle to grave. 3 = coherent LCA for some products of interest 1 = streamlined LCA for some products of interest-
5	**scope**		
6	**functional unit**		
7	**system boundaries (stages and process cut-off)**		
8	**assumptions (e.g. allocation)**		
9	**data sources and quality** **1. Raw materials** **2. Manufacturing** **3. Distribution/transportation** **4. Use phase** **5. Packaging** **6. End of Life**		S_{DATA} I) Temporal, Geographical and Technological representativeness, evaluated <u>for each stage</u>: 5 = High quality -Data refers to less than 3 years ago. -Data for specific country of interest and relevant for the EU Ecolabel. -Data for specific technology used and of relevance for the EU Ecolabel 3 = Average quality -Data refers to 3–5 years. -Average data at continental level and relevant for the EU Ecolabel. -Data reflecting the average technologies used 1 = Low quality -Data refers to more than 5 years ago. -Average data at World level. -Data related to technologies not often used. II) The <u>overall score</u> for data is the average of the points assigned to each single stage.
10	**Impact assessment categories/methods**	✓ Satisfactory broadness (at least one indicator is of interest with respect to the indicators identified earlier) AND quality of all the indicator(s) of interest used is classified at least as "C" according to the ILCD handbook.	$S_{IMPACTS}$ 5 = satisfactory broadness (with respect to the impact categories identified earlier) AND all indicators of interest are evaluated as A or B (best in class) according to ILCD 3 = at least one indicator is of interest (with respect to the indicators identified earlier) AND all indicators of interest are evaluated as A or B (best in class) according to ILCD 1 = at least one indicator is of interest (with respect to the indicators identified earlier) AND all the indicators used evaluated as C (average class) according to ILCD.

11	**Conclusions (e.g. most important life lifecycle phases; most important drivers to impacts - process/material; improvement options)**	✓The outcomes of the study must be relevant and applicable to the revision process.	$S_{OUTCOMES}$ 5 = The outcomes of the study are of high relevance for the criteria revision and they can be directly used to address some key-issues. 3 = The outcomes are somehow of relevance for the criteria revision and they can be directly used to address some key-issues. 1 = The outcomes are somehow of relevance for the criteria revision and they can be partially used to address some key-issues.
12	**Strength and weakness of the whole study, general comments**		$S_{ROBUSTNESS}$ 5 = The overall quality of the study is considered good and sensitivity analysis is performed to analyse and manage most important sources of uncertainty and variability. 3 = The overall quality of the study is considered good (in terms of modelling, assumptions, data gaining, impacts assessment, presentation and discussion of results, findings). 1 = Minimal requirements of quality are satisfied.
13	**Subject to independent review?**		S_{REVIEW} 5 = independent 3rd-party review (e.g. certification) 3 = independent review (e.g. paper) 1 = no review

Table 49. Classification of midpoint (M) and endpoint(E) Impact category methods

Impact category	Default LCIA method according to ILCD	Classification of default method according to ILCD (I, II, III)	Methods evaluation (Overall evaluationof science based criteria). (M) = midpoint; (E)= endpoint				
			A	B	C	D	E
Climate change	Baseline model of 100 years of the IPCC (2007)	recommended and satisfactory (I)	IPCC[227] (M)	Recipe[228] (E)	EPS2000[229] (E) Ecoind99[230] (E) LIME[231] (E)	-	-
Ozone depletion	Steady-state ODPs 1999 as in WMO[232] assessment	recommended and satisfactory (I)	WMO (M)	Recipe(E) LIME (E)	Ecoind99 (E)	EPS2000 (E)	-
Acidification	Accumulated Exceedance (Seppälä et al. 2006,[233] Posch et al, 2008)[234]	recommended but in need of some improvements (II)	Accumulated Exceedance	CML (M) Recipe (M)	Recipe (E) Ecoind99 (E) LIME (E)		TRACI (M) EDIP 2003 MEEUP[235] LIME (M)
Photochemical ozone formation	LOTOS-EUROS (Van Zelm et al, 2008)[236] as applied in ReCiPe	recommended but in need of some improvements (II)	-	Recipe (M) EDIP2003[237] LIME (M) CML[238] (M) TRACI[239] (M) EcoSense[240] (E) LIME (E) Recipe (E)	-	-	-
Eutrophication, terrestrial	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	recommended but in need of some improvements (II)	Accumulated Exceedance	CML 2002 (M) EDIP2003 EPS2000 (E) Ecoind99 (E)	-	-	-
Eutrophication, aquatic	EUTREND model (Struijs et al, 2009b)[241] as implemented in ReCiPe	recommended but in need of some improvements (II)	-	EDIP2003aqu LIME (M/E) ReCiPe (M/E) TRACI (M) CML (M) EPS2000 (E) IMPACT 2002+ (E)	-	-	-

7.3.APPENDIX III: Candidate list of substances of very high concern

According to the table below, currently there are 144 substances on the Candidate list of substances of very high concern. The last updated was in 20th June 2013:

Table 50. Candidate list Substances of Very High Concern

Substance Name	EC Number	CAS Number	Date of inclusion	Reason for inclusion
Cadmium	231-152-8	7440-43-9	20/06/2013	Carcinogenic (Article 57a); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Ammonium pentadecafluorooctanoate (APFO)	223-320-4	3825-26-1	20/06/2013	Toxic for reproduction (Article 57 c); PBT (Article 57 d)
Pentadecafluorooctanoic acid (PFOA)	206-397-9	335-67-1	20/06/2013	Toxic for reproduction (Article 57 c); PBT (Article 57 d)
Dipentyl phthalate (DPP)	205-017-9	131-18-0	20/06/2013	Toxic for reproduction (Article 57 c);
4-Nonylphenol, branched and linear, ethoxylated			20/06/2013	Equivalent level of concern having probable serious effects to the environment (Article 57 f)
Cadmium oxide	215-146-2	1306-19-0	20/06/2013	Carcinogenic (Article 57a); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Hexahydromethylphthalic anhydride [1], Hexahydro-4-methylphthalic anhydride [2], Hexahydro-1-methylphthalic anhydride [3], Hexahydro-3-methylphthalic anhydride [4]	247-094-1, 243-072-0, 256-356-4, 260-566-1	25550-51-0, 19438-60-9, 48122-14-1, 57110-29-9	19/12/2012	Equivalent level of concern having probable serious effects to human health (Article 57 f)
6-methoxy-m-toluidine (p-cresidine)	204-419-1	120-71-8	19/12/2012	Carcinogenic (Article 57a)
Cyclohexane-1,2-dicarboxylic anhydride [1], cis-cyclohexane-1,2-dicarboxylic anhydride [2], trans-cyclohexane-1,2-dicarboxylic anhydride [3] covered by this entry]	201-604-9, 236-086-3, 238-009-9	85-42-7, 13149-00-3, 14166-21-3	19/12/2012	Equivalent level of concern having probable serious effects to human health (Article 57 f)
Pyrochlore, antimony lead yellow	232-382-1	8012-00-8	19/12/2012	Toxic for reproduction (Article 57 c)
Henicosafluoroundecanoic acid	218-165-4	2058-94-8	19/12/2012	vPvB (Article 57 e)
4-Aminoazobenzene	200-453-6	60-09-3	19/12/2012	Carcinogenic (Article 57a)
Silicic acid, lead salt	234-363-3	11120-22-2	19/12/2012	Toxic for reproduction (Article 57 c)
Lead titanium zirconium oxide	235-727-4	12626-81-2	19/12/2012	Toxic for reproduction (Article 57 c)
Lead monoxide (lead oxide)	215-267-0	1317-36-8	19/12/2012	Toxic for reproduction (Article 57 c)
o-Toluidine	202-429-0	95-53-4	19/12/2012	Carcinogenic (Article 57a)
3-ethyl-2-methyl-2-(3-methylbutyl)-1,3-oxazolidine	421-150-7	143860-04-2	19/12/2012	Toxic for reproduction (Article 57 c)
Dibutyltin dichloride (DBTC)	211-670-0	683-18-1	19/12/2012	Toxic for reproduction (Article 57 c)

Substance Name	EC Number	CAS Number	Date of inclusion	Reason for inclusion
Lead bis(tetrafluoroborate)	237-486-0	13814-96-5	19/12/2012	Toxic for reproduction (Article 57 c)
Lead dinitrate	233-245-9	10099-74-8	19/12/2012	Toxic for reproduction (Article 57 c)
Silicic acid	272-271-5	68784-75-8	19/12/2012	Toxic for reproduction (Article 57 c)
Trilead bis(carbonate)dihydroxide	215-290-6	1319-46-6	19/12/2012	Toxic for reproduction (Article 57 c)
4,4'-methylenedi-o-toluidine	212-658-8	838-88-0	19/12/2012	Carcinogenic (Article 57a)
Diethyl sulphate	200-589-6	64-67-5	19/12/2012	Carcinogenic (Article 57a); Mutagenic (Article 57b)
Dimethyl sulphate	201-058-1	77-78-1	19/12/2012	Carcinogenic (Article 57a)
N,N-dimethylformamide	200-679-5	68-12-2	19/12/2012	Toxic for reproduction (Article 57 c)
4-(1,1,3,3-tetramethylbutyl)phenol, ethoxylated	-	-	19/12/2012	Equivalent level of concern having probable serious effects to the environment (Article 57 f)
4-Nonylphenol, branched and linear	-	-	19/12/2012	Equivalent level of concern having probable serious effects to the environment (Article 57 f)
Furan	203-727-3	110-00-9	19/12/2012	Carcinogenic (Article 57a)
Lead oxide sulfate	234-853-7	12036-76-9	19/12/2012	Toxic for reproduction (Article 57 c)
Lead titanium trioxide	235-038-9	12060-00-3	19/12/2012	Toxic for reproduction (Article 57 c)
Bis(pentabromophenyl) ether (decabromodiphenyl ether; DecaBDE)	214-604-9	1163-19-5	19/12/2012	PBT (Article 57 d); vPvB (Article 57 e)
Dinoseb (6-sec-butyl-2,4-dinitrophenol)	201-861-7	88-85-7	19/12/2012	Toxic for reproduction (Article 57 c)
1,2-Diethoxyethane	211-076-1	629-14-1	19/12/2012	Toxic for reproduction (Article 57 c)
N-methylacetamide	201-182-6	79-16-3	19/12/2012	Toxic for reproduction (Article 57 c)
Tetralead trioxide sulphate	235-380-9	12202-17-4	19/12/2012	Toxic for reproduction (Article 57 c)
Acetic acid, lead salt, basic	257-175-3	51404-69-4	19/12/2012	Toxic for reproduction (Article 57 c)
[Phthalato(2-)]dioxotrilead	273-688-5	69011-06-9	19/12/2012	Toxic for reproduction (Article 57 c)
Tetraethyllead	201-075-4	78-00-2	19/12/2012	Toxic for reproduction (Article 57 c)
N-pentyl-isopentylphthalate	-	776297-69-9	19/12/2012	Toxic for reproduction (Article 57 c)
Pentalead tetraoxide sulphate	235-067-7	12065-90-6	19/12/2012	Toxic for reproduction (Article 57 c)
Heptacosafluorotetradecanoic acid	206-803-4	376-06-7	19/12/2012	vPvB (Article 57 e)
Tricosafluorododecanoic acid	206-203-2	307-55-1	19/12/2012	vPvB (Article 57 e)
1-bromopropane (n-propyl bromide)	203-445-0	106-94-5	19/12/2012	Toxic for reproduction (Article 57 c)
Dioxobis(stearato)trilead	235-702-8	12578-12-0	19/12/2012	Toxic for reproduction (Article 57 c)
Pentacosafluorotridecanoic acid	276-745-2	72629-94-8	19/12/2012	vPvB (Article 57 e)
Methoxyacetic acid	210-894-6	625-45-6	19/12/2012	Toxic for reproduction (Article 57 c)
Methyloxirane (Propylene oxide)	200-879-2	75-56-9	19/12/2012	Carcinogenic (Article 57a); Mutagenic (Article 57b)
Trilead dioxide phosphonate	235-252-2	12141-20-7	19/12/2012	Toxic for reproduction (Article 57 c)
o-aminoazotoluene	202-591-2	97-56-3	19/12/2012	Carcinogenic (Article 57a)
4-methyl-m-phenylenediamine (toluene-2,4-diamine)	202-453-1	95-80-7	19/12/2012	Carcinogenic (Article 57a)

Substance Name	EC Number	CAS Number	Date of inclusion	Reason for inclusion
Diisopentylphthalate	210-088-4	605-50-5	19/12/2012	Toxic for reproduction (Article 57 c)
1,2-Benzenedicarboxylic acid, dipentylester, branched and linear	284-032-2	84777-06-0	19/12/2012	Toxic for reproduction (Article 57 c)
Biphenyl-4-ylamine	202-177-1	92-67-1	19/12/2012	Carcinogenic (Article 57a)
Fatty acids, C16-18, lead salts	292-966-7	91031-62-8	19/12/2012	Toxic for reproduction (Article 57 c)
Orange lead (lead tetroxide)	215-235-6	1314-41-6	19/12/2012	Toxic for reproduction (Article 57 c)
4,4'-oxydianiline and its salts	202-977-0	101-80-4	19/12/2012	Carcinogenic (Article 57a); Mutagenic (Article 57b)
Diazene-1,2-dicarboxamide (C,C'-azodi(formamide))	204-650-8	123-77-3	19/12/2012	Equivalent level of concern having probable serious effects to human health (Article 57 f)
Sulfurous acid, lead salt, dibasic	263-467-1	62229-08-7	19/12/2012	Toxic for reproduction (Article 57 c)
Lead cyanamidate	244-073-9	20837-86-9	19/12/2012	Toxic for reproduction (Article 57 c)
Î±,Î±-Bis[4-(dimethylamino)phenyl]-4 (phenylamino)naphthalene-1-methanol (C.I. Solvent Blue 4)	229-851-8	6786-83-0	18/06/2012	Carcinogenic (Article 57a)
1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (Î²-TGIC)	423-400-0	59653-74-6	18/06/2012	Mutagenic (Article 57b)
N,N,N',N'-tetramethyl-4,4'-methylenedianiline	202-959-2	101-61-1	18/06/2012	Carcinogenic (Article 57a)
Diboron trioxide	215-125-8	1303-86-2	18/06/2012	Toxic for reproduction (Article 57 c)
1,2-bis(2-methoxyethoxy)ethane (TEGDME; triglyme)	203-977-3	112-49-2	18/06/2012	Toxic for reproduction (Article 57 c)
Formamide	200-842-0	75-12-7	18/06/2012	Toxic for reproduction (Article 57 c)
4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol <em>	209-218-2	561-41-1	18/06/2012	Carcinogenic (Article 57a)
Lead(II) bis(methanesulfonate)	401-750-5	17570-76-2	18/06/2012	Toxic for reproduction (Article 57 c)
[4-[4,4'-bis(dimethylamino) benzhydrylidene]cyclohexa-2,5-dien-1-ylidene]dimethylammonium chloride (C.I. Basic Violet 3)	208-953-6	548-62-9	18/06/2012	Carcinogenic (Article 57a)
1,2-dimethoxyethane; ethylene glycol dimethyl ether (EGDME)	203-794-9	110-71-4	18/06/2012	Toxic for reproduction (Article 57 c)
[4-[[4-anilino-1-naphthyl][4-(dimethylamino)phenyl] methylene]cyclohexa-2,5-dien-1-ylidene] dimethylammonium chloride (C.I. Basic Blue 26)	219-943-6	2580-56-5	18/06/2012	Carcinogenic (Article 57a)
1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)	219-514-3	2451-62-9	18/06/2012	Mutagenic (Article 57b)
4,4'-	202-027-5	90-94-8	18/06/2012	Carcinogenic (Article 57a)

Substance Name	EC Number	CAS Number	Date of inclusion	Reason for inclusion
bis(dimethylamino)benzophenone				
Phenolphthalein	201-004-7	77-09-8	19/12/2011	Carcinogenic (article 57 a)
N,N-dimethylacetamide	204-826-4	127-19-5	19/12/2011	Toxic for reproduction (article 57 c)
4-(1,1,3,3-tetramethylbutyl)phenol	205-426-2	140-66-9	19/12/2011	Equivalent level of concern having probable serious effects to the environment (article 57 f)
Lead diazide, Lead azide	236-542-1	13424-46-9	19/12/2011	Toxic for reproduction (article 57 c),
Lead dipicrate	229-335-2	6477-64-1	19/12/2011	Toxic for reproduction (article 57 c)
1,2-dichloroethane	203-458-1	107-06-2	19/12/2011	Carcinogenic (article 57 a)
Calcium arsenate	231-904-5	7778-44-1	19/12/2011	Carcinogenic (article 57 a)
Dichromium tris(chromate)	246-356-2	24613-89-6	19/12/2011	Carcinogenic (article 57 a)
2-Methoxyaniline; o-Anisidine	201-963-1	90-04-0	19/12/2011	Carcinogenic (article 57 a)
Pentazinc chromate octahydroxide	256-418-0	49663-84-5	19/12/2011	Carcinogenic (article 57 a)
Zirconia Aluminosilicate Refractory Ceramic Fibres	-	-	19/12/2011	Carcinogenic (article 57 a)
Arsenic acid	231-901-9	7778-39-4	19/12/2011	Carcinogenic (article 57 a)
Potassium hydroxyoctaoxodizincatedichromate	234-329-8	11103-86-9	19/12/2011	Carcinogenic (article 57 a)
Formaldehyde, oligomeric reaction products with aniline	500-036-1	25214-70-4	19/12/2011	Carcinogenic (article 57 a)
Lead styphnate	239-290-0	15245-44-0	19/12/2011	Toxic for reproduction (article 57 c)
Bis(2-methoxyethyl) phthalate	204-212-6	117-82-8	19/12/2011	Toxic for reproduction (article 57 c)
Trilead diarsenate	222-979-5	3687-31-8	19/12/2011	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Aluminosilicate Refractory Ceramic Fibres	-	-	19/12/2011	Carcinogenic (article 57 a)
Bis(2-methoxyethyl) ether	203-924-4	111-96-6	19/12/2011	Toxic for reproduction (article 57 c)
2,2'-dichloro-4,4'-methylenedianiline	202-918-9	101-14-4	19/12/2011	Carcinogenic (article 57 a)
Cobalt dichloride	231-589-4	7646-79-9	2011/06/20 - 2008/10/28	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich	276-158-1	71888-89-6	20/06/2011	Toxic for reproduction (article 57c)
Strontium chromate	232-142-6	02/06/7789	20/06/2011	Carcinogenic (article 57a)
1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear alkyl esters	271-084-6	68515-42-4	20/06/2011	Toxic for reproduction (article 57c)
1-Methyl-2-pyrrolidone	212-828-1	872-50-4	20/06/2011	Toxic for reproduction (article 57c)
1,2,3-Trichloropropane	202-486-1	96-18-4	20/06/2011	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
2-Ethoxyethyl acetate	203-839-2	111-15-9	20/06/2011	Toxic for reproduction (article 57c)
Hydrazine	206-114-9	302-01-2, 7803-57-8	20/06/2011	Carcinogenic (article 57a)
Cobalt(II) diacetate	200-755-8	71-48-7	15/12/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
2-Ethoxyethanol	203-804-1	110-80-5	15/12/2010	Toxic for reproduction (article 57c)
Cobalt(II) sulphate	233-334-2	10124-43-3	15/12/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)

Substance Name	EC Number	CAS Number	Date of inclusion	Reason for inclusion
Acids generated from chromium trioxide and their oligomers.	231-801-5, 236-881-5	7738-94-5, 13530-68-2	15/12/2010	Carcinogenic (article 57a)
2-Methoxyethanol	203-713-7	109-86-4	15/12/2010	Toxic for reproduction (article 57c)
Chromium trioxide	215-607-8	1333-82-0	15/12/2010	Carcinogenic and mutagenic (articles 57 a and 57 b)
Cobalt(II) carbonate	208-169-4	513-79-1	15/12/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Cobalt(II) dinitrate	233-402-1	10141-05-6	15/12/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Trichloroethylene	201-167-4	79-01-6	18/06/2010	Carcinogenic (article 57 a)
Potassium dichromate	231-906-6	7778-50-9	18/06/2010	Carcinogenic, mutagenic and toxic for reproduction (articles 57 a, 57 b and 57 c)
Tetraboron disodium heptaoxide, hydrate	235-541-3	12267-73-1	18/06/2010	Toxic for reproduction (article 57 c)
Boric acid	233-139-2, 234-343-4	10043-35-3, 11113-50-1	18/06/2010	Toxic for reproduction (article 57 c)
Ammonium dichromate	232-143-1	05/09/7789	18/06/2010	Carcinogenic, mutagenic and toxic for reproduction (articles 57 a, 57 b and 57 c)
Sodium chromate	231-889-5	03/11/7775	18/06/2010	Carcinogenic, mutagenic and toxic for reproduction (articles 57 a, 57 b and 57 c)
Disodium tetraborate, anhydrous	215-540-4	1303-96-4, 1330-43-4, 12179-04-3	18/06/2010	Toxic for reproduction (article 57 c)
Potassium chromate	232-140-5	7789-00-6	18/06/2010	Carcinogenic and mutagenic (articles 57 a and 57 b).
Acrylamide	201-173-7	79-06-1	30/03/2010	Carcinogenic and mutagenic (articles 57 a and 57 b)
Lead sulfochromate yellow (C.I. Pigment Yellow 34)	215-693-7	1344-37-2	13/01/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c))
Lead chromate molybdate sulphate red (C.I. Pigment Red 104)	235-759-9	12656-85-8	13/01/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
2,4-Dinitrotoluene	204-450-0	121-14-2	13/01/2010	Carcinogenic (article 57a)
Anthracene oil	292-602-7	90640-80-5	13/01/2010	Carcinogenic¹, PBT and vPvB (articles 57a, 57d and 57e)
Anthracene oil, anthracene paste, anthracene fraction	295-275-9	91995-15-2	13/01/2010	Carcinogenic², mutagenic³, PBT and vPvB (articles 57a, 57b, 57d and 57e)
Anthracene oil, anthracene-low	292-604-8	90640-82-7	13/01/2010	Carcinogenic², mutagenic³, PBT and vPvB (articles 57a, 57b, 57d and 57e)
Diisobutyl phthalate	201-553-2	84-69-5	13/01/2010	Toxic for reproduction (article 57c)
Tris(2-chloroethyl)phosphate	204-118-5	115-96-8	13/01/2010	Toxic for reproduction (article 57c)
Lead chromate	231-846-0	7758-97-6	13/01/2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Anthracene oil, anthracene paste	292-603-2	90640-81-6	13/01/2010	Carcinogenic², mutagenic³, PBT and vPvB (articles 57a, 57b, 57d and 57e)
Pitch, coal tar, high temp.	266-028-2	65996-93-2	13/01/2010	Carcinogenic, PBT and vPvB (articles 57a, 57d and 57e)
Anthracene oil, anthracene paste,distn.	295-278-5	91995-17-4	13/01/2010	Carcinogenic², mutagenic³, PBT and

Substance Name	EC Number	CAS Number	Date of inclusion	Reason for inclusion
lights				vPvB (articles 57a, 57b, 57d and 57e)
Lead hydrogen arsenate	232-064-2	7784-40-9	28/10/2008	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Benzyl butyl phthalate (BBP)	201-622-7	85-68-7	28/10/2008	Toxic for reproduction (article 57c)
Bis (2-ethylhexyl)phthalate (DEHP)	204-211-0	117-81-7	28/10/2008	Toxic for reproduction (article 57c)
Bis(tributyltin)oxide (TBTO)	200-268-0	56-35-9	28/10/2008	PBT (article 57d)
5-tert-butyl-2,4,6-trinitro-m-xylene (musk xylene)	201-329-4	81-15-2	28/10/2008	vPvB (article 57e)
Diarsenic trioxide	215-481-4	1327-53-3	28/10/2008	Carcinogenic (article 57a)
Triethyl arsenate	427-700-2	15606-95-8	28/10/2008	Carcinogenic (article 57a)
Diarsenic pentaoxide	215-116-9	1303-28-2	28/10/2008	Carcinogenic (article 57a)
Sodium dichromate	234-190-3	7789-12-0, 10588-01-9	28/10/2008	Carcinogenic, mutagenic and toxic for reproduction (articles 57a, 57b and 57c)
Dibutyl phthalate (DBP)	201-557-4	84-74-2	28/10/2008	Toxic for reproduction (article 57c)
4,4'-Diaminodiphenylmethane (MDA)	202-974-4	101-77-9	28/10/2008	Carcinogenic (article 57a)
Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins)	287-476-5	85535-84-8	28/10/2008	PBT and vPvB (articles 57 d and 57 e)
Anthracene	204-371-1	120-12-7	28/10/2008	PBT (article 57d)
Hexabromocyclododecane (HBCDD) and all major diastereoisomers identified	247-148-4 and 221-695-9	25637-99-4, 3194-55-6 (134237-50-6) (134237-51-7) (134237-52-8)	28/10/2008	PBT (article 57d)

Source: European Chemicals Agency website

7.4. APPENDIX IV: Hazard statements according to article 6(6) of EU Ecolabel legislation EC/66/2010

According to the Article 6(6) of EU Ecolabel legislation EC/66/2010[242], the product or any part of it thereof shall not contain substances or mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with CLP Regulation (EC) No 1272/2008, nor to goods containing substances referred to in Article 57 of REACH Regulation. The list of hazard statements according to CLP for hazardous substances which are excluded from the EU ecolabelled products is provided below:

Table 51. Hazard statements according to article 6(6) of EU Ecolabel legislation EC/66/2010

Hazard statement according to CLP 1272/2008/EEC	Associated risk phrases according to Directive 67/548/EEC
H300 Fatal if swallowed	R28
H301 Toxic if swallowed	R25
H304 May be fatal if swallowed and enters airways	R65
H310 Fatal in contact with skin	R65

Hazard statement according to CLP 1272/2008/EEC	Associated risk phrases according to Directive 67/548/EEC
H311 Toxic in contact with skin	R65
H330 Fatal if inhaled	R23; R26
H331 Toxic if inhaled	R23
H340 May cause genetic defects	R23
H341 Suspected of causing genetic defects	R68
H350 May cause cancer	R45
H350i May cause cancer by inhalation	R49
H351 Suspected of causing cancer	R40
H360F May damage fertility	R60
H360D May damage the unborn child	R61
H360FD May damage fertility. May damage the unborn child	R60-61
H360Fd May damage fertility. Suspected of damaging the unborn child	R60-63
H360Df May damage the unborn child. Suspected of damaging fertility	R61-62
H361f Suspected of damaging fertility	R62
H361d Suspected of damaging the unborn child	R63
H361fd Suspected of damaging fertility. Suspected of damaging the unborn child	R62-63
H362 May cause harm to breast-fed children	R64
H370 Causes damage to organs	R39/23; R39/24; R39/25; R39/26; R39/27; R39/28
H371 May cause damage to organs	R68/20; R68/21; R68/22
H372 Causes damage to organs through prolonged or repeated exposure	R48/25; R48/24; R48/23
H373 May cause damage to organs through prolonged or repeated exposure	R48/20; R48/21; R48/22
H400 Very toxic to aquatic life	R50
H410 Very toxic to aquatic life with long-lasting effects	R50-53
H411 Toxic to aquatic life with long-lasting effects	R51-53
H412 Harmful to aquatic life with long-lasting effects	R52-53
H413 May cause long-lasting harmful effects to aquatic life	R53
EUH059 Hazardous to the ozone layer	R59
EUH029 Contact with water liberates toxic gas	R29
EUH031 Contact with acids liberates toxic gas	R31
EUH032 Contact with acids liberates very toxic gas	R32
EUH070 Toxic by eye contact	R39-41
H334 May cause allergy or asthma symptons or breathing difficulties if inhaled	R42
H317 May cause allergic skin reaction	R43

Source: European Chemicals Agency website

7.5. APPENDIX V: Overview of transformation production processes in the wood furniture sector

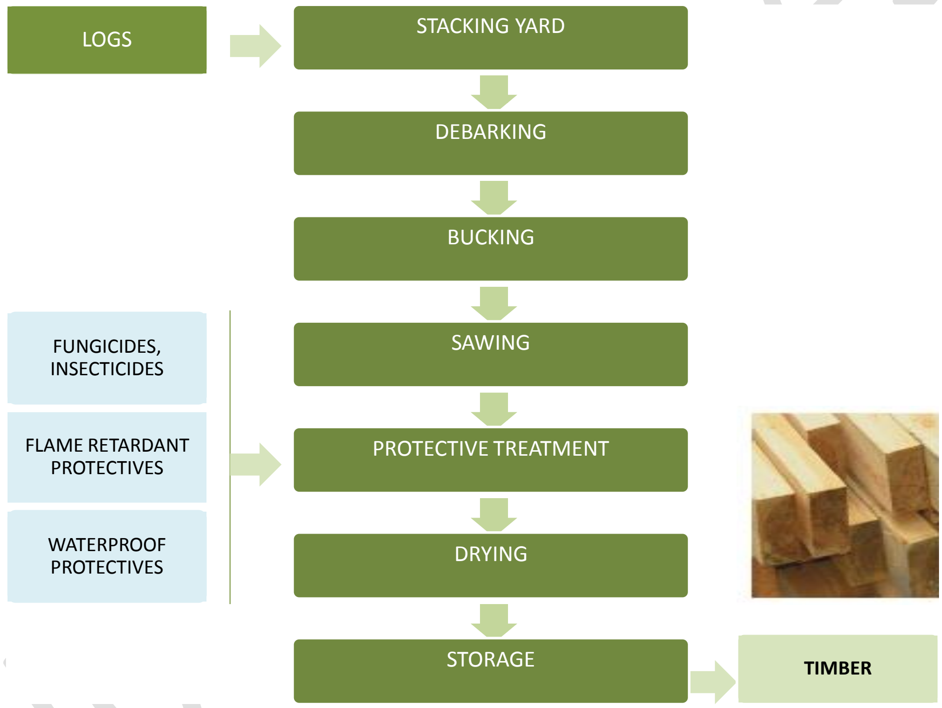
Main substances applied in the different transformation production processes in the wood furniture sector have been identified below:

First transformation production process in wood furniture sector

SAWMILL

Fungicides, insecticides additivated or not with flame retardants and waterproof protectives are used for wood preservatives.

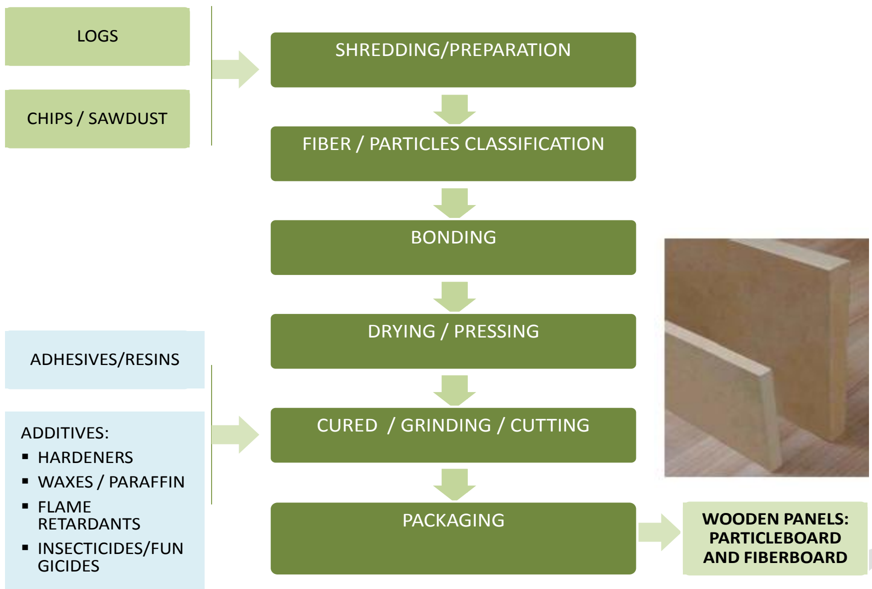
Figure 39. Sawmill: First transformation production processes in wood furniture sector



Source: Guidance on REACH regulation in wood furniture industry

WOODEN PANELS: PARTICLEBOARD AND FIBREBOARD

Figure 40. Wood panels: Particleboard and fibreboard: First transformation production process in wood furniture sector



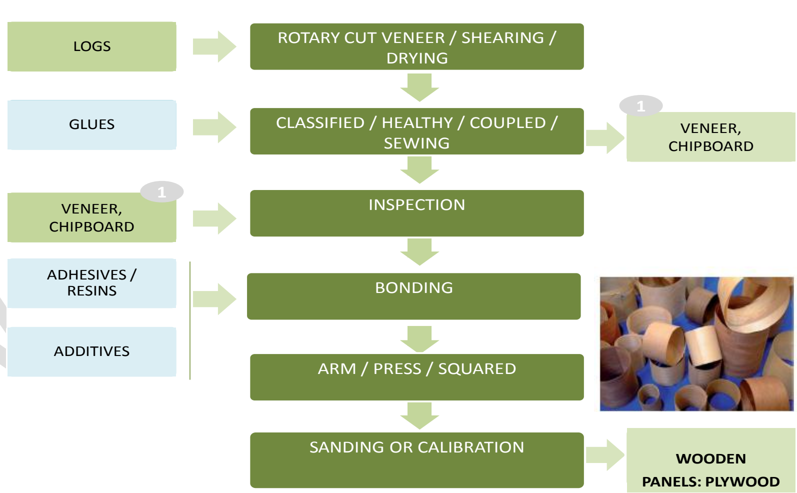
Source: Guidance on REACH regulation in wood furniture industry

WOODEN PANELS: PLYWOOD

Plywood is wooden panels produced under heat and pressure with the addition of an adhesive to sheets of wood.

As stated above in particleboard and fiberboard, additives used in plywood are also flame retardants, adhesives-resins and biocides such as wood preservatives or insecticides.

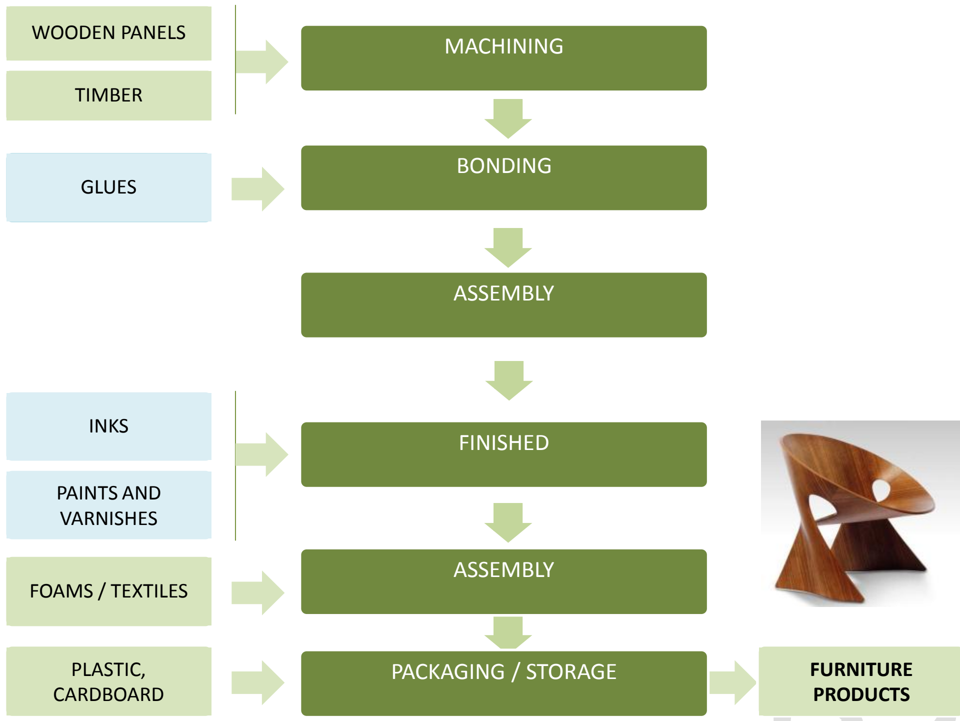
Figure 41. Wood panels: Plywood: First transformation production process in wood furniture sector



Source: Guidance on REACH regulation in wood furniture industry29

Second transformation production process in wood furniture sector

Figure 42. Second transformation production process in wood furniture sector



Source: Guidance on REACH regulation in wood furniture industry[30]

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The Market Access Database is an important operational tool of the European Union's Market Access Strategy which has been used to provide an overview of trade flows (imports and exports) between EU-27 and non-EU countries for furniture.

Eurostat: http://epp.eurostat.ec.europa.eu/
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