Environmental aspects of timber

STEP lecture A16
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Objectives

To give a global overview of the major potential environmental impacts of timber, in all stages of the life cycle (from "cradle to grave"). To discuss the method for assessment of environmental impact.

Summary

The environmental aspects of building materials, and thus of timber, are gaining more weight as selection criteria for application in constructions. As this is a relatively new research area, methods for assessment of the environmental impact of wood are under development (e.g. Life cycle assessment). The environmental aspects of timber in general are regarded as positive, as compared to other building materials, the main reasons being that

- wood is a renewable material,
- the European forest is a sustainable source of timber,
- the positive effect on the Global Warming or Greenhouse Effect of the earth, by reducing the CO_2 level during production in forests and by replacement of fossil fuel by wood in the waste stage,
- the general low energy requirements for production,
- the potential for reuse, recycling or energy production, thus producing a minimum of waste.

The areas that need more environmentally friendly alternatives are gluing, wood preservation and coating. Emission of organic volatile compounds (e.g. formaldehyde, hydrocarbons) from glues and paints and emission of components from preservatively treated timber are the major potential environmental risk factors.

Introduction

Environmental aspects have become, along with technical and economic aspects, increasingly important in the evaluation of products. Environmental aspects have gained more and more attention in legislation, product approvals, standardization, and in the consumers' choices and preferences. Environmental labelling systems are increasing and different steering measures are being introduced in order to reduce the overexploitation of natural resources and to avoid pollution and environmental risks.

Environmental assessments of materials and products

Environmental consequences of the use of a certain material or a product must be evaluated from "cradle to grave", that means over the whole life cycle of the product. In the assessment, the consumption of materials and energy and the effluents to the environment over the life span are considered. The methodology of the life cycle assessment (LCA) of materials and products is still in the developing phase. A number of LCA methods have been proposed, some of them mainly concentrating on the inventory of environmental data over the life cycle, some also

proposing steps for the evaluation of environmental consequences. It is, however, very difficult to establish uniform criteria for the assessment of different types of environmental impacts. The need for guidelines for LCA has been identified and among others, the Society of Environmental Toxicology and Chemistry as well as standardization organisations ISO and CEN are working in order to produce a code of practice.

In this paper, environmental aspects of timber and wood products are discussed excluding pulp and paper. Wood products are mainly used for building and construction, for packaging and for furniture. Previously few LCA studies have been made for wood products. The environmental assessment of wood products should include harvesting and transport of wood raw material, industrial manufacture of the product, transport to the site of use, building process or installation, period of use including maintenance, demolition and management of wastes. For each stage, an input-output calculation shall be made and the total environmental effect evaluated on the basis of the calculations.

In order to evaluate the environmental impacts of the use of timber one should also be able to compare those impacts with the use of other, alternative materials. The most important alternatives for timber and wood products are concrete and other mineral materials, steel, aluminium and other metallic materials as well as plastic materials and different composite materials.

It is generally accepted, that wood has environmentally favourable properties in comparison with many substitutes. The most important fact is that wood is a renewable raw material. Wood products require relatively little energy and cause little pollution to the environment. It is no longer, however, adequate to refer to these qualitative statements; the environmental impacts must be confirmed quantitatively. In the future all producers will have to demonstrate the consumption of energy and resources as well as the emissions to the environment caused by their products.

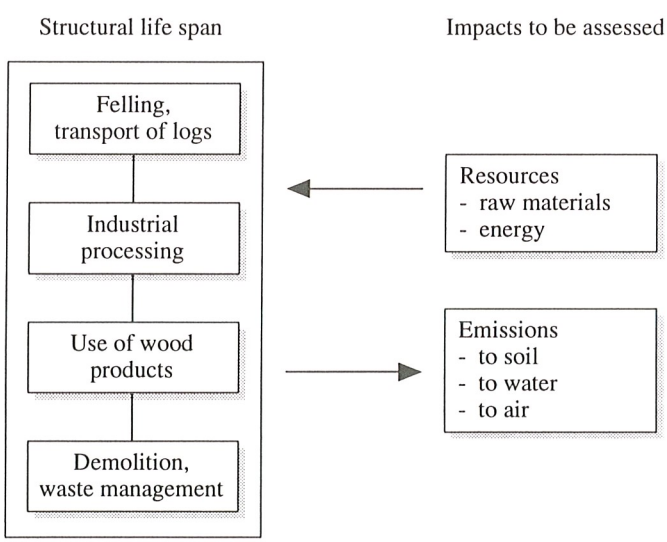

Figure 1 *Life cycle assessment of wood products.*

Timber resources and harvesting

The world's forested area is estimated to be about 5 billion hectares, of which just under 3 billion hectares are closed forests. Over half of the forests are in temperate

and cold areas. Historically, man has destroyed and reduced forests on enormous areas by clearing land for agriculture and other uses and by forest felling. It has been estimated that only about one third of the world's original forests still exist. The rate of deforestation during the last decade has been about 17 million hectares per year. Deforestation is mainly taking place in tropical forests which disappear by 1,8% per year (Dudley 1992).

Also Europe has seen large scale forest losses in the past, particularly in the south and in the Mediterranean area. Currently, the forest cover is estimated to be around 160 million hectares (the European part of the former USSR is not included). Contrary to the historical generalisation above, the last 100 years have been a period of net gain due to positive afforestation and conservation legislation. Also the annual growth of forests per unit area has been increasing thanks to effective silviculture and forest improvement. The estimated amount of timber in the European forests in 1990 was 18,5 billion m^3. The annual net increment in 1990 was estimated at 584 m^3, which is 20% bigger than the estimate in 1980. The annual production of roundwood in Europe in 1990 was nearly 400 million m^3 which is about 11% of the total world production. The annual harvesting in Europe is 25-30% smaller than the annual net increment (FAO 1992).

Deforestation and forestry practices have become items of serious concern in the international environmental debate. The disappearance of forests is a most serious ecological threat to the earth and most countries have now bound themselves to sustainable forestry. Also, the member countries of the International Tropical Timber Organization (ITTO) have decided that the international tropical timber trade should be brought to a basis of sustainable production by the year 2000. Earlier, the maintenance of the productive capacity of forests has been emphasized as the main measure of sustainability. In the future it will be necessary to pay attention to more complex environmental goals such as protection of the forest ecosystem as a whole, conservation of biodiversity (abundance of species) and protection of cultural, recreational and aesthetic values. The United Nations Conference on Environment and Development (UNCED) in Rio in 1992 produced a number of decisions for the protection of forests. Also, the users of timber have started to demand guarantees for that the timber originates from a sustainable forest.

Logging changes the ecology and environmental conditions of the forest in many ways. Numerous forest plant and animal species require specific habitats in order to flourish. In today's Europe there is very little native or old growth forest left. Native forest areas and special biotopes are, as a rule, excluded from commercial exploitation or placed under regulated timber production. The issue of the sufficiency of conservation areas and natural parks has, however, been a subject of constant debate.

In Europe, commercial forests are normally well tended. Confrontations have emerged, however, between the forestry practices used, clear cutting in particular, and noncommercial forest values. The forestry sector has taken heed of the criticism and management practices have been modified to be more compatible with natural phenomena. It continues to be a challenge to European forestry to develop and improve utilization methods that are both efficient and based on the principles of sustained yield accompanied by a keen awareness of environmental issues. To ensure this, European countries have increased international efforts in research (e.g. European Forestry Institute established in 1992) and created monitoring mechanisms (e.g. Ministerial Conference on the Protection of Forests

in Europe in 1992).

An existing threat to the European forests is the decline in tree health caused by the impact of atmospheric pollution and acid deposition. In particular, northern conifer forests are sensitive to air pollution. International cooperation is absolutely necessary in order to reduce pollution.

Forestry and greenhouse effect

Wood material is formed by the assimilation by trees of carbon dioxide, water and solar energy. Wood is an important part of the short-term carbon cycling on Earth. Atmospheric carbon dioxide fixed by trees is first stored in living trees and later in wood products for hundreds of years. By deterioration or combustion the carbon is released back in to the atmosphere and fixed again by trees.

Carbon dioxide is the most important of so called "greenhouse gases" in the atmosphere. Its concentration in the atmosphere is constantly increasing because of the increased use of fossil fuels. The increase of greenhouse gases causes warming of climate which is considered to be one of the most important environmental problems ahead us. There are also indications that the increase of carbon dioxide may play a role in the depletion of the ozone layer particularly in the northern hemisphere. In order to act against the greenhouse phenomenon an international agreement (entering into force in 1994) has been made to oblige countries to reduce emissions from fossil fuels. The greenhouse phenomenon can also be reduced by increasing the binding of carbon dioxide in forests and in other biomass. This has actually happened in Europe as the surplus of annual increment over annual felling in forests has increased. However, the net fixation of carbon dioxide cannot be increased simply by reducing the felling. An old forest will reach a saturation point where the fixation is balanced by the release of carbon dioxide by decay.

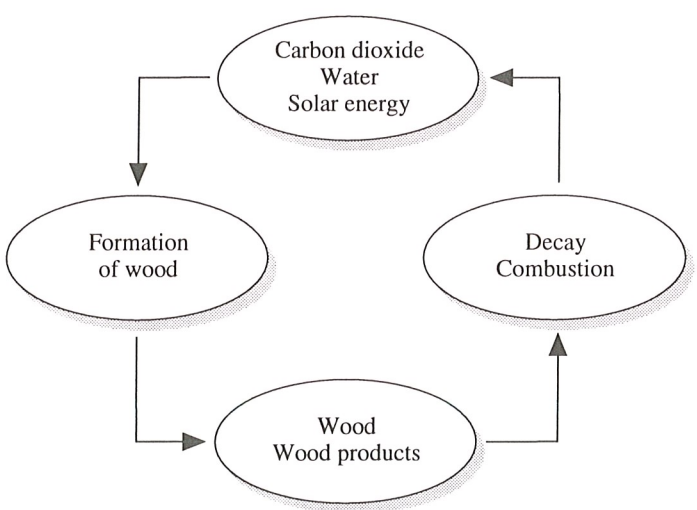

Figure 2 Wood is a renewable raw material that is automatically recycled by nature.

In the combustion of wood solar-derived energy is released to be used for the production of heat or electricity in order to substitute for fossil fuels. The carbon dioxide released by combustion does not increase the net carbon dioxide level of the atmosphere because only the same carbon dioxide is released back that was originally bound from the air into the wood material. This carbon dioxide would, in any case find its way into the atmosphere even if wood were not used for energy production but left to decay. On the other hand, the increase in the amount of

carbon dioxide in the air will be restrained, if renewable wood material is used to substitute for fossil fuels or as an alternative for products which require more fossil fuels in production.

Environmental impacts of forest industry

From the environmental point of view, every industry should make the most of its raw materials while minimizing the harmful effects on the environment.

Wood material is utilized fairly completely by the forest industries even if large amounts of by-products and waste wood are produced in single processes. The yield of sawn timber for instance is only about 50% of the round wood volume, but the byproducts are used for the production of pulp and paper, reconstituted boards etc. Bark and other wastes unsuitable for raw material are utilized for energy production.

The manufacture of wood products requires in general less energy than the manufacture of alternative products of other materials. It is very difficult to give exact figures of energy consumption because the production systems may vary widely. The figures presented in the literature often lack information on the means of calculation and on the system boundaries. Regarding the pollution resulting from the energy production, the source of energy used is very decisive. A considerable proportion of the energy in the wood industry is produced by burning bark and wood wastes, about 80% in the sawmilling industry. Even if the energy demand in the wood industry is low, there still is a continuous need to strive for energy economies in order to keep the advantage. The production phases that require most energy are drying of wood and heat pressing (panel products).

Material	Primary energy content	
	kWh/kg	*kWh/m^3*
Sawn timber	0,7	350
Glulam	2,4	1200
Particle board	3,4	2210
Fibreboard	3,4	3400
Plywood	5,4	3240
Cement	1,4	1750
Concrete	0,3	700
Bricks	0,8	1360
Gypsum board	2,4	1820
Steel	5,9	46000
PVC plastic	18,0	24700
PU plastic	40,0	1800
Aluminium	52,0	141500

Table 1 *Examples of the primary energy contents of some building materials. The figures may vary widely depending on the actual processing systems.*

Among the different industrial branches, forest product industries are considered fairly harmless to the environment. In the sawmilling industry, environmental impacts are caused by water storage of logs because of dissolving bark and wood substances. Environmental problems are also caused by noise, smell and handling of wastes. The most serious environmental problems have been connected with the use of toxic blue-stain preservatives (chlorinated phenols in particular), which may have polluted soil and watercourses. These have nowadays been replaced in most

countries in Europe by less harmful chemicals and the need for their use has diminished due to efficient kiln drying practices.

Even if the qualitative environmental problems are fairly well known in the sawmilling industry, much more research is needed in order to find out quantitative emissions into soil, water and air. Research needs regarding the effects of floating, water storage of logs and barking, impacts of blue-stain preservatives, emissions from drying kilns and from energy production, dust, mould spores and volatile organic emissions from wood should be considered.

In the joinery and furniture industries, problems to the environment are caused by different additive materials, by hydrocarbon emissions to the air, noise, dust and waste treatment. The most acute problem is surface finishing. Currently used finishes and lacquers are mainly based on organic solvents. The new European directives will presume significant reduction of organic solvent emissions, which will require installation of cleaning equipment or change of finishing systems. Today the general trend is towards water-based and bio-based finishing systems.

In the panel products industry, problems are caused by adhesives that may create harmful emissions and problem wastes. Problems may also emerge from coatings and various additive materials.

From the environmental point of view, one of the problem areas of the forest industry is timber impregnation plants. The most used chemicals have been CCA-salts and creosote oil. These give good durability to timber but are more and more considered questionable from the environmental point of view. In many old plants soil and sometimes even ground waters have been contaminated by toxic preservatives. Due to more advanced technology, better environmental protection and waste management, the conditions are usually satisfactorily controlled in modern plants.

A new European standard for treated timber is under preparation. It will include a whole range of impregnation classes so that the level of protection is better adjusted to the need of protection for the particular end-use. Development work is under way in order to find new, environmentally more friendly concepts for preservation.

Transport

Logging and transport of logs require some energy (oil, diesel fuel) and cause disturbance and destruction to the forest nature. Nowadays, vegetable oils may be used instead of diesel oil in harvesters. The transport of logs and of finished products accounts for only a small share, usually only a few percent, of the total energy consumption and emissions over the life cycle of forest products. For environmental calculation, data on the means of transportation, the average distances and types of fuels used are needed.

Wood in use

Timber and wood products are generally safe in use and cause very little effect on the environment during utilization.

In recent years there has been growing interest in the health and safety aspects of the indoor climate and building materials. Many building materials emit different volatile organic compounds (VOC) that may cause health problems. The knowledge of the emissions from different materials is still very poor. Regarding wood-based

products, formaldehyde emissions from certain adhesives and finishing materials have created most concern. The problem was most acute in the case of urea-formaldehyde glued particleboards. Nowadays, very strict regulations have been set upon the formaldehyde emissions from products and the problem has been overcome by changes in the glue composition and in the manufacturing processes.

Wood contains small amounts of different extractive compounds, e.g. terpene compounds, that are volatile and may be perceived as the typical smell of fresh wood. The amounts emitted are very small and depend upon the age of the wood surface. No connections have been proven between these emissions and health problems but some of the terpene compounds are considered to produce allergic effects.

Durability of a product is also an environmental aspect because it may dictate the service life of the product. Timber constructions when properly designed have good durability. If the moisture stresses are too high, unprotected wood is susceptible to biological deterioration like growth of mould and decay fungi. As well as reducing durability, growing fungi produce bad smells and their spores may give rise to health problems.

Demolition and waste management

Increasingly strict requirements for the management and reduction of wastes are expected to affect all producers more and more in the future. Nowadays, the building sector produces large amounts of waste both at the building site and on demolition. There is a growing demand for increased reuse and recycling of building materials.

After the first period of use, timber or wood products can be reused in other constructions, recycled (manufactured into new products like reconstituted boards) or used for energy production.

From the point of view of waste management, wood has an advantage over many materials in that it is easily degraded biologically in nature. However, reuse or recycling or utilization for energy production should, as a rule, be preferred to disposal by dumping.

Considerable environmental advantages can be gained by increased utilization of wood products for energy production after the period of use as a construction material. The theoretical energy content of wood varies with moisture content and density. The effective thermal value of dry wood fuel is 5,3 - 5,5 *kWh/kg*. Combustion of wood produces, in general, similar emissions to combustion of other fuels. The main difference is that wood combustion does not produce notable sulphur emissions. The quality and amount of emissions depend upon the burning conditions. High temperatures are required for complete combustion of organic compounds. Wood ash can be used for soil fertilization.

Burning of moist wood or improper combustion conditions can result in high emissions of carbon monoxide and hydrocarbons. Special requirements are set on the burning of wood products including chemical preservatives, certain adhesives or additives, which may produce toxic emissions or in the case of inorganic compounds, concentrate in the ash.

Wooden products and constructions are seldom made of pure wood but combined with several other materials, which may make reuse or recycling more difficult.

There is a need to pay more attention to the aspects of reuse and waste management already in product development, planning and design phases.

Concluding summary

- Wood is a renewable raw material when it originates from a sustainable forest. Wood material is formed in living trees from carbon dioxide and water by means of solar energy.

- European forestry is based on sustainable yield. However, there is a need to develop the forestry practices further so that felling will cause as little destruction to the natural environment as possible.

- The use of renewable wood material will help to reduce reliance on the remaining resources of nonrenewable materials.

- It is environmentally sound to use timber from European forests efficiently. If the forests are underexploited, timber has to be substituted by other materials which are likely to produce more impact on the environment than the use of timber.

- Forest industries cause relatively little pollution to the environment and the impact is further diminishing with the modernization of the production processes. The industry should, however, monitor the amounts of effluents and other impacts more closely and continue to minimize these impacts.

- Regarding forest products, environmental concerns are often caused by materials other than wood: preservatives, adhesives, finishes etc. Development work is needed to introduce environmentally more friendly alternatives to many of the present materials.

- Wood is easily degraded in nature, which is an advantage concerning waste management. Wooden wastes should, however, in the first place be reused, recycled or utilized for energy production. As wood material forms a part of the short-term carbon cycling, the combustion of wood does not increase the net level of carbon dioxide in the air. The increase in the level of carbon dioxide can be counteracted by using wood to substitute for fossil fuels or for products that require more fossile fuels in production.

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