Solar Energy and Urban Planning

Building with Timber - Contributing to the mitigation of global CO_2 emissions

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1. Introduction

Since the Rio-Conference in 1992 society faces new challenges and tasks based on the Conference issues and statements. Key-words such as sustainable development, conservation of finite resources, protection of our natural basis of subsistence and cyclic economies indicate that, next to technical and economic demands on production processes, technologies and products the social impact of ecological criteria is greater to-day than it has been in the past.

Ecology may be considered the science of the relationship of living beings to their environment. It makes firm demand on society to commit itself to act with the greatest possible consideration to the environment and hence in the most holistic manner possible.

This, in turn, has a direct impact on civil engineering with its deep and longterm influence on our cultural, social and economic way of life and on the character of villages, towns and the countryside. Building has always been a reflection of society's cultural and spiritual set of values. In the context of growing environmental awareness the ecological aspects of building materials and the question whether they will be environmentally compatible in the future must be considered, next to architectural requirements, building styles and technical criteria of constructions and materials. In civil engineering, too, "what makes good ecological sense" will have to take the place of "what is technically possible". This is by no means an argument against technology, but rather in favour of ecologically well-founded, intelligent techniques.

Ecology requires new criteria for building materials to be taken seriously such as raw material extraction and supply ("what are the sources of our raw materials?") and product manufacture ("what are the relevant technologies?"). How do building materials behave while they are being used, where and how can they ultimately be disposed of or integrated into (artificial or natural) cycles?

2. Building and dwelling under ecological principles - the role of wood

The above considerations require a new line of thinking as far as construction activities and the role of wood in future construction and dwelling are concerned. Building will always be associated with negative environmental impacts, the cause also being that the relationship between constructing and related effects on the environment have not been taken into proper account in the past 50 years. At the time was much more important to build as fast and cheaply as possible with "modern" materials than to study environmental aspects and to act accordingly.

The entire range of building materials used, selected or certified by builders, architects, town planners and communal authorities should be subjected to a comprehensive evaluation. For most building materials technical and technological data are more easily available than their corresponding ecological characteristics and this is where life cycle assessment will play an eminent role in the future. Internationally, a great amount of work has meanwhile gone into perfecting life cycle assessment, making it an acknowledged tool. A detailed description was published elsewhere (e.g. Wegener et al. 1997, Frühwald et al. 1997).

3. Ecological advantages of wood

In the context of the new sense of responsibility for mankind, nature and technology wood and modern wood-based materials are becoming more and more important. Life cycle assessment shows wood and wood-based materials to have a great number of advantages apart from the well-known positive technical characteristics. The latter include, inter alia, custom-made, well-dried solid wood elements in desired qualities, dimensions and strengths, added-value, machine-graded sawnwood with up to 50 % increase in load-bearing capacity, durable wood species and reliable designs that make wood preservation measures almost superfluous, wood-based rods and boards with high, oriented strength properties.

Life cycle assessment deals with the entire life cycle of products or building materials. This also includes all the technical processes that went into their manufacture.

The starting point for the life cycle of wood as a raw, working and building materials is always the forest. Hence, from an ecological point of view, wood has an outstanding position among all other resources. Not only is wood a sustainably renewable raw material, based on its unique production conditions in the forest wood is itself an integral part of the forest ecosystem.

To-day, about the same quantities of carbon, present in the atmosphere in the form of CO_2 are being stored in earth's current biomass (plants, animals, humans). Over 80 % of this amount of carbon is stored in the forests of this earth (Burschel 1990). Ideally, natural forest, so-called primordial forests keep up a state of equilibrium, i.e. the fixation and the release of carbon as CO_2 are balanced. In this type of forest the carbon sink is full and can store no further amounts of carbon dioxide from the atmosphere (Fig. 1).

It is through forest management and the use of wood that carbon stored in the forests is extracted and room made for new carbon dioxide to be sequestered from the atmosphere (Fig. 2). In this process the uptake of CO_2 is directly related to the increment in biomass (wood, leaves, roots etc.). Timber from the forest is used in products and for energy purposes and thus serves as a substitute for fossil raw materials and fuels.

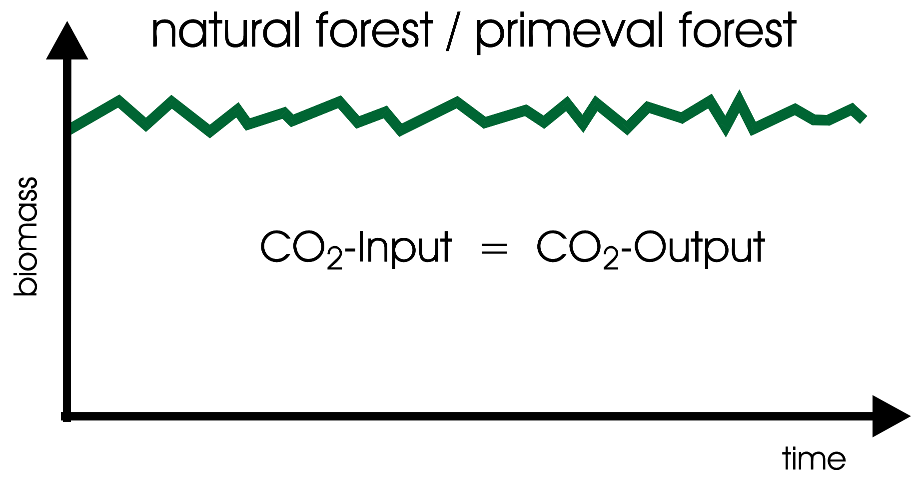

Fig. 1: Biomass development in natural forests that are in a state of equilibrium, i.e. they are producing the same amount of biomass as is being decomposed. Their carbon sinks are therefore full and no further atmospheric carbon dioxide can be sequestered (after Burschel 1987).

Abb. 1: Biomasseentwicklung in Primärwäldern und sogenannten Urwäldern, die sich in einer Fließgleichgewichtsphase befinden und in der gleichzeitig genausoviel Biomasse produziert wie abgebaut wird. Der Kohlenstoffspeicher ist aufgefüllt, es kann der Atmosphäre kein zusätzliches CO_2 mehr entzogen werden (nach Burschel 1987).

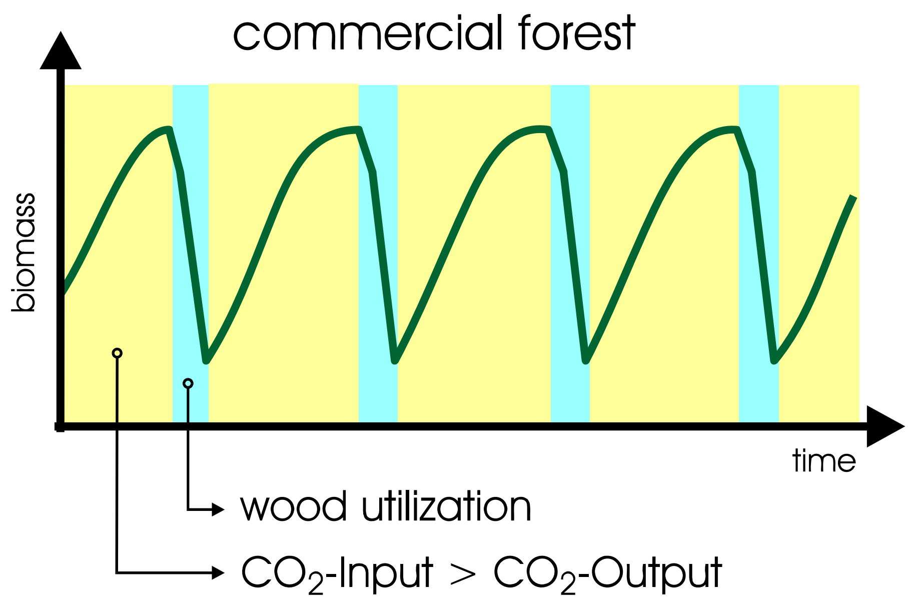

Fig. 2: Biomass development in managed forests, whose carbon sinks are being continually deplenished, making room for further CO_2 sequestered from the atmosphere (after Burschel 1987).

Abb. 2: Biomasseentwicklung eines bewirtschafteten Waldes, dessen Kohlenstoffspeicher durch Holznutzung immer wieder entleert wird, was ihn in die Lage versetzt, der Atmosphäre zusätzliches CO_2 zu entziehen (nach Burschel 1987).

The use of wood in large amounts and the greatest possible number of products leads to the mitigation of anthropogenic CO_2 emissions and to a reduction in the rise in atmospheric CO_2. At the end of the service life of any wood product the chemical elements of wood can be returned into the natural cycle by burning, as a source of energy, or by biological decomposition. The carbon dioxide taken from the atmosphere in the process of wood formation through photosynthesis is then returned to the atmosphere. While the solar energy stored in wood is not being made use of in the process of biological degradation, e.g. in compost, the use of wood as fuel as a substitute for fossil resources produces the effect of further mitigating CO_2 emissions (Fig. 3)

Under the aspect of global climate conservation the closed CO_2 cycle of wood production and utilization is the key to the solution of the CO_2 problem.

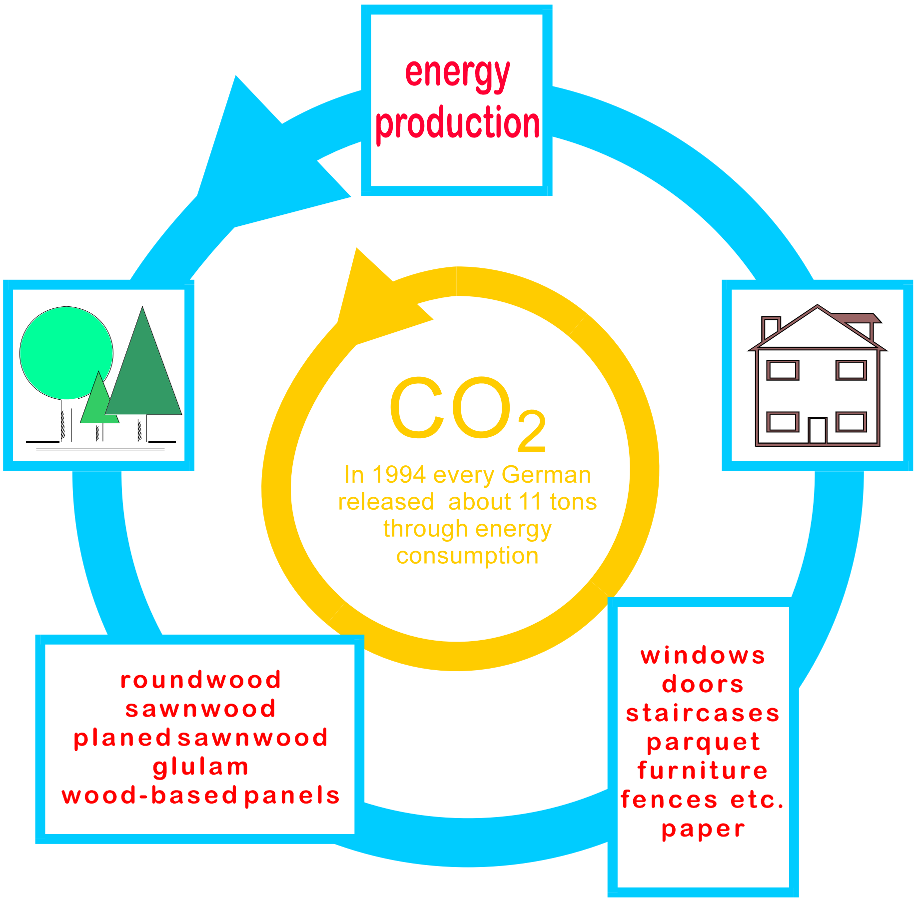

Fig. 3: Total cycle of wood utilization which corresponds to the CO2 cycle. (e.g. Wegener et al. 1997, Frühwald et al. 1997).

Abb. 3: Der Gesamtkreislauf Holznutzung und -verwendung, der dem CO2-Kreislauf entspricht (e.g. Wegener et al. 1997, Frühwald et al. 1997).

Another important ecological advantage is the fact that there are practically no waste materials in wood production and manufacture but only re-usable products and fuel. Take sawnwood production: Apart from the main product "sawnwood" there are by-products such as bark, chips and sawdust. Bark may either be used in the plant's fuelling system and supply part of the power and thermal energy required in sawnwood production or it may be sold off for mulch and compost production. Likewise, fine or coarse chips may find use in the manufacture of wood-based products (e.g. particleboard, MDF and other fibreboards) or in the production of

mechanical and chemical pulps in the paper industry. Chips are also used in brick-making to produce thermal insulation elements. Another possible use is as a source of energy. How these by-products are being used is usually a question of operational policies - at any rate none of these by-products are waste materials that require special methods of disposal as stipulated by the Recycling and Waste Materials Act.
At the end of service life of wood products there are, once again, different ways of making further use of them. One is socalled "material use", i.e. recycling. Another, open to all wood products, is to make use of them for fuelling purposes. Biological degradation (e.g. in a waste dump) would be possible but is no longer permitted under the Recycling and Waste Materials Act. Biological degradation would also mean that no use is being made of the solar energy stored in the wood product.

The life cycle assessment of a product comprises the material and energy flows in the course of its entire life cycle. Important aspects of this life cycle are the conservation of finite resources, energy and CO_2-reducing effects. The production of wood in the forest requires merely 1 to 4 % fossile energy in relation to the solar energy stored in the wood. Hence CO_2 emissions for logging, sawmilling and technical drying processes of sawn timber are proportionately low. In the further course of product life cycle more energy has to be expended and this entails CO_2-emissions in the course of roundwood transport, processing in sawmills and technical drying of sawnwood. Again related to the energy stored in the wood, the overall energy consumed in dried sawnwood production is no more than 11 to 18 %.

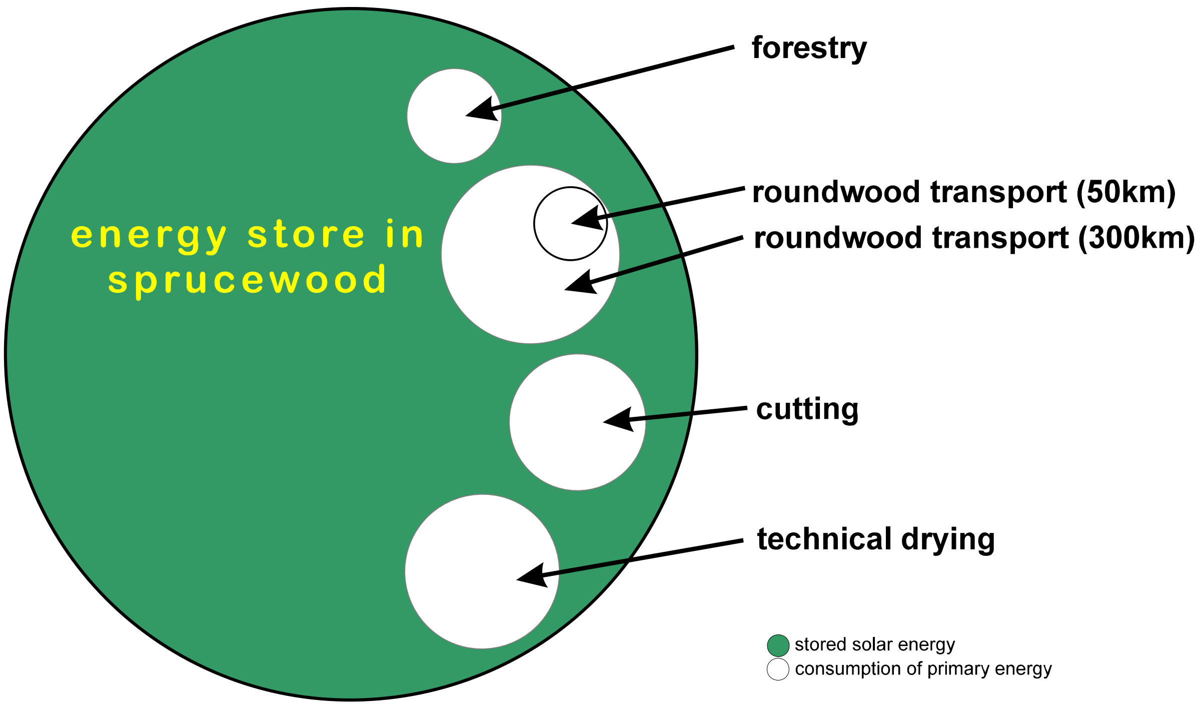

Fig. 4: Energy balance for the production of coniferous sawnwood. The areas of the white circles represent the percentage of fossil energy expended in relation to the energy stored in wood.

Abb. 4: Energiebilanz für die Produktion von Nadelschnittholz. Die Flächen der weißen Kreise stellen den Anteil der Energie (fossil) dar, der in Relation zur im Holz gespeicherten Energie aufgewendet werden muß.

The Life Cycle Assessment e.g. of glulam, based on these data, demonstrates that even wood products with high added value and specific qualities as required for building purposes have a uniquely positive energy balance.

In the manufacture of glulam all waste wood is consistently being used as fuel (effectivity of the fuel plant (KWK) 82 % related to energy content). Into the production of 1 m^3 glulam go 2.48 m^3 spruce roundwood.

Table 1: Part of the energy balance for the production of 1 m^3 glulam. Consistent use of the waste wood from the production process for fuelling shows the potential of wood for substituting fossil fuels.

Tabelle 1: Ausschnitt aus der Energiebilanz zur Herstellung von 1m³ Brettschichtholz. Die konsequente energetische Nutzung der anfallenden Resthölzer zeigt das Substitutionspotential des Energieträgers Holz

Energy consumption	Energy [MJ ($E_{äq}$)]
forestry	306
roundwood transport (50 km)	200
sawnwood production	360
transport (600 km, 50% capacity)	2400
glulam manufacture incl. sawnwood drying	4275
total:	7541
Energy production	
utilization of waste wood	
electrical energy thermal energy	2154 6678
Energy surplus:	1291

Glulam manufacture hence consumes less energy than can be used from the waste wood (Table 1.) This calculation does not even take into account the energy content of glulam itself (8,299 MJ) also available for use at the end of its long service life.

Apart from all the positive effects in the course of their service life -inter alia thermal insulation properties - all wood products represent usable energy stores prior to ultimate disposal.

In short, any use of wood and wood products will be of considerable ecological advantage compared with that of raw materials that do not sequester CO_2 and have no CO_2-reducing and energy-saving potential.

A great step towards making use of these advantages, in particular in construction, is to officially certify the ecological characteristics of building materials. Data from Life Cycle Assessments contribute towards strengthening the conviction held by consumers, architects, town planners, engineers and building authorities that not only is wood one of the oldest structural materials on this planet but also the building material of the future in a hospitable environment.

4. Literature

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