Evaluation of timber as building materials on energy issue and the Woodmiles: the background and the development of the Woodmiles Forum in Japan

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Abstract

About a half of newly constructed houses in Japan have wooden structure and timber is considered to be one of the important building materials. One of the features of timber as building materials is that very little amount of energy is consumed under production process. On the other hand, it is pointed out that the energy consumption during timber transportation processes though long distances is quite larger than that of its production processes.

In order to shorten the transportation distance of the timber used for construction, the Woodmiles Forum was launched, in Japan. The forum is aiming at the development and promotion of the indexes relating to the distance between the place of harvest of timber and the place of building.

The Forum proposes several indexes, including the Woodmileage which represent a sum of the products between the volumes of wooden materials of a house multiplied by the corresponding actual transportation distances between the place of harvest of the timber used for the residence, and the Woodmileage CO_2 showing the quantity of CO_2 discharged in transportation processes.

It has been two years since the woodmiles movement began in Japan. The knowledge on the indexes have spread throughout Japan during that period, in practical, administrative and academic field.

The concept of woodmiles would be one of the key words to evaluate the environmental load for building and transparency of the link between the consumers and the forests.

Keywords: woodmiles, woodmileage, CO_2 discharge, transportation, energy consumption,

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1. Introduction

In order to evaluate environmental load of buildings, in Japan as well as other countries, sophisticated methods including various kinds of Life Cycle Assessments are being developed[1]. These methods are to be adopted as a means of reducing environmental loads from the construction sites where its building areas reach up to 170 million m^2 per annum in Japan.

Up until now it cannot be said that methods developed have spread enough or that there has been enough reward from massive amounts of efforts. One reason as pointed out is the difficulty for users of such methods to interpret results from an evaluation despite methods such as LCA aiming to be quite comprehensive.

The woodmiles index, to be dealt in this paper, was developed by the Woodmiles Forum in Japan to evaluate some aspects of the environmental load of building materials. It may be limited because this index has a restricted range of timber transport distances if considering this index in regards to evaluations of the environmental loads from buildings. However, it could give us an opportunity for propagation, because
1) this index provides its users with a simple index of environmental load and
2) this index provides a measurement for forming a network of supply of building materials.

We would like to explain the background of this development, its method of evaluation, its interpretation of results from the evaluation and so forth of the woodmiles index. And we hope those will contribute much to the fruitful discussions on the evaluation of environmental loads from buildings.

2. Timber building materials in Japan and its evaluation based on energy consumption

2.1 Building trends in Japan and trends of wooden frame buildings

In Japan, 173 million m^2 of buildings were built in 2003, 63 million m^2 of them were wooden frame buildings. In particular, in the same year, among 104 million m^2 and 1160 thousand units new residential houses, wooden frame houses have 56.3million m^2, 523 thousand units and account for 54.2% and 45.1% respectively of all new houses.

Table 2-1 Trend of Construction Starts of Dwellings

	units			area (thousand m^2)		
year	Total	Wooden frame	share	Total	Wooden frame	share
1993	1,485,684	697,496	46.9%	131,683	75,116	57.0%
2003	1,160,083	523,192	45.1%	104,038	56,348	54.2%

Min. of Land, Infrastructure and Transport, “The Survey on Bldg. Construction Started”

The agricultural areas has more wooden frame dwellings than the urban areas, and the total ratio of wooden frame houses has slightly decreased in 1980s due to the recent trend in urbanization. However it has been stable arround 45% since 1990s. (Table 2-1)

If we analyze an opinion survey on the preference of house[2], we can see that many Japanese people prefer wooden frame dwelling houses. (Table 2-2)

Table2-2 Preference of house construction

Type of Structure	Preference
Wooden Frame, Traditional	67.0 %
Wooden Frame, 2x4	21.5 %
Non Wooden Frame	7.7 %
No answer	3.8 %

Office of Public Relation, Cabinet Office of Japan 2003

As described above, wooden frame structures play an important part in building activities in Japan so its trend will not change in the future. Timber itself is one of the most important building materials in Japan.

2.2 Evaluation of timber energy consumptions and promotion of timber

It is pointed out that one of the features of timber as a building material is its efficiency of energy consumption in production processes. Nakajima, S. and Okuma, M. reported that the quantity of carbon emitted from the production of one cubic meter of timber is fur smaller than that of other construction materials[3]. (Table 2-3)

Table 2-3 Energy consumption and CO_2 discharge in production process of construction materials

Material	Fossil energy consumed		CO_2-discharged	
	MJ/kg	MJ/m^3	kg/t	kg/ m^3
Sawn timber air dried	1.5	750	110	55
Sawn timber kiln dried	2.8	1390	205	103
Plywood	12	6000	799	440
Particle board	20	10000	1129	733
Steel	35	266000	2567	19507
Aluminum	435	1100000	31900	80667
Concrete	2	4800	183	440

Nakajima, S. and Okuma, M. 1991

In comparison with each quantity of carbon dioxide discharged from the production of building materials for such three kinds of building structures as wooden frame, reinforced concrete and steel frame, Okuma, M. pointed out that the quantity of carbon dioxide from the production of building materials for a reinforced concrete house is 4.2 times as much as the

wooden frame house, and the carbon dioxide for the steel frame house is 2.9 times as much as the wooden frame house.[4] (Table 2-4)

Table 2-4 Carbon Discharge on Production of Materials for Construction of a House by Type of Construction

Materials	Wooden Frame		RC		Steel	
	kg-c		kg-c		kg-c	
Timber						
Sawn Timber	1282.0	24.9%	234.6	1.1%	293.6	2.0%
Plywood	260.3	5.1%	425.3	1.9%	199.6	1.4%
Total	1542.3	30.0%	659.9	3.0%	493.2	3.3%
Steel	792.5	15.4%	7067.8	32.4%	8817.1	59.8%
Concrete	2805.1	54.6%	14087.0	64.6%	5432.7	36.8%
Grand Total	5140.0	100.0%	21814.7	100.0%	14743.0	100.0%

Okuma, M. *"Preservation of Global Environment and Wood Utilization"*, P.71, in Japanese

Based upon such examination, the timber industry in recent years carries out a campaign promoting timber as an eco-material[5] supported by the related administration. In the Annual Report 2003 on Trends of Forest and Forestry published by Forest Agency of Japan, there is a feature article of "Toward the new Generation of Wood". The article states that timber is an eco-material that is reproductive with little impact to the environment and is carbon neutral.

3. Sources of timber supply and their distances

3.1 Sources of supply of timber used in Japan and the environmental load from timber transportation

In 2002, the demand for timber (sawn timber) for Japan was 34,856 thousand cubic meters (log equivalent basis). 70% was used as building materials. From sources of supply, 39% of its supply was imported to Japan as sawn timber and 29% of its supply was imported as logs for sawing. Domestic timber accounts for 32% of the supply[6].

Main sources of imported timber of Japan are North America, South East Asia, Russia(Asian), Europe and New Zealand. The Table 3-1 shows results of calculations that average the quantity of carbon dioxide discharged from distances of their transportation and its process of transportation, after analyzing routes of transportations of timbers from its origin[7]. (Table 3-1)

Table 3-1 Distance and CO_2 discharged of transportation of imported timber

Origin	Distance of Transportation km							CO_2 kg/ m^3
	Total	Sawn Product			Raw Log			
		boat	car	rail	boat	car	rail	
North America	8064	7710	254	0	0	100	0	111
South East Asia	5174	4920	254	0	0	0	0	71

Russia	7675	1921	254	5000	0	500	0	177
Europe	23274	22570	254	350	0	100	0	227
New Zealand	9770	9116	554	0	0	100	0	160

Fujiwara, T. et al.(2004)

Timber from Europe, the farthest major origins from Japan, travels 23 thousand kilometres. 227 kilograms of carbon dioxide per one cubic meter of timber is discharged from its transporting process. Fig. 3-1 shows a comparison of this figure with the quantity of carbon dioxide discharged from the production process described in above Section 2[8]. It is clear that transportation of timber through long distances has more environmental load than the production process of the timber has.

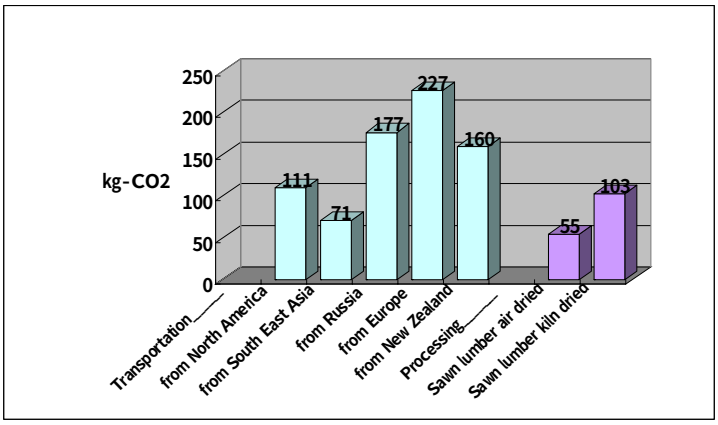

Fig. 3-1 CO_2 discharged on transportation and production process
Source: The Woodmiles Forum (2004)

3.2 Comparison of timber transportation distances by importing countries

Further, Fujiwara, T. compared the transportation distances of timbers in importing processes for three countries Japan, U.S.A. and Germany, using the statistics of trading 2000 by the Food and Agriculture Organization. The U.S.A. imported the largest quantity of timber in the world and Germany imported largest quantity of timber in Europe. The Table 3-2 shows respective quantities of imported timber for each country by distances from the origins[9].

Table 3-2 Timber Importation of major importing countries by distance form origin

thousand cubic meters

Distance from origin	Japan		USA		Germany	
Total import of timber	52009	100.0%	60357	100.0%	22790	100.0%
-1000km	0	0.0%	55889	92.6%	9378	41.1%
1000-8000km	33393	64.2%	2845	4.7%	13074	57.4%
8000km-	18616	35.8%	1623	2.7%	338	1.5%

Fujiwara, T. “Woodmiles and house constructed with local timber”,

If the distance of transportation is divided into three categories, U.S.A., which imported 93% from Canada depends the most imported timber on the nearest sources. Although U.S.A. has imported valuable timber such as *Mahogany* and *Teak* from South-East Asian countries more than 10,000 kilometres away, it only comprises 3% of the total amount of timber imported. On the other hand, Japan is one of the few countries that import substantial amount of timber from countries more than 10,000 kilometres away. If we introduce a concept of total transporting distance that multiplies imported quantity of timbers and transporting distances, though the quantity of imported timbers for Japan would be less than that for U.S.A., the total transporting distances for Japan would be more than 4 times as much as those of U.S.A[10]. (Fig. 3-2)

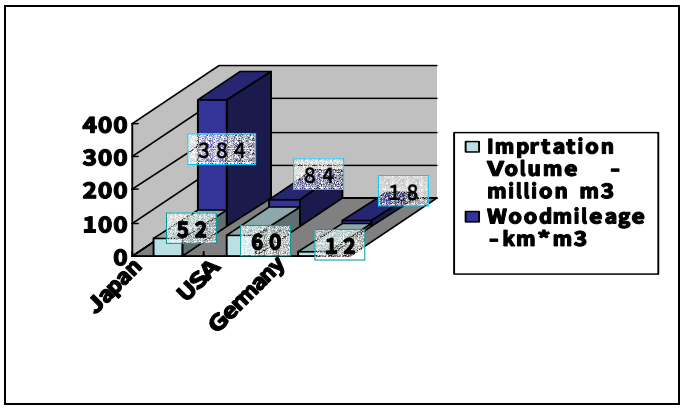

Fig. 3-2 Comparison of woodmileage of imported timber

4. Development of the woodmiles index

4.1 The Woodmiles Forum

As described above, the energy consumed for the transportation process of timber is a critical factor in environmental loads and it is especially an important problem to Japanese consumers. As this problem was brought to their attention the Woodmiles Forum (here in after refereed as “the Forum”) was founded in June, 2003.
The purpose of the Forum is the development and promotion of the woodmiles index in order to shorten transportation distances of timber used for building houses and to revitalize local timber consumption. The Forum's goal is to contribute to realize the sustainable society by promoting the use of local resources in Japan[11].

4.2 The woodmiles index for the building and its structure

To achieve its objectives mentioned above, The Forum developed a manual to provide a reproducible and objective method for the calculation of "Woodmiles Index for Building".
The manual revised in December 2004 defines the following four indexes for evaluation of building construction.

Building Woodmileage

Actual distance covered in transporting timber of the applicable type used in the construction of a building (hereafter, applicable timber materials) from each place of harvest (timber type-specific wood miles) multiplied by the respective volumes of timber transported from each place of harvest (unit: km m^3)

Building Woodmileage CO_2

CO_2 emissions equivalent to the energy expended in covering the above distances according to the types of transportation used (road, rail, sea, etc.) for each form of timber (unprocessed or processed) (unit: kg- CO_2)

Building Woodmileage L (L = linear)

The linear distance from each place of harvest (timber type-specific wood miles L) of applicable timber materials to the construction site, multiplied by the respective volumes of timber transported from each place of harvest (unit: km m^3)

Logistics stops knowledge level

The degree, expressed as a proportion of total wood mileage, of applicable timber materials for which knowledge of processing and storage stops on the way from each place of harvest to construction site enables the calculation of an accurate woodmileage figure

Because most timber used in house construction goes through a complicated series of transporting and processing stages, it is invariably only the sawmill that carried out final processing that is easily knowable, and very little information is available on procurement and passage of the unprocessed timber. However, this manual demands the maximum possible elucidation of the processing and storage stops on the way from place of harvest to the construction site, together with reasonably concrete measurement of distances between stops, the form of the timber transported (raw logs, processed timber), and type of transportation used (road, rail, sea) for each stage. As such, those calculating the indexes will need to trace the routes taken by the timber used through enquiring at the sawmills, and then the unprocessed timber market sources involved. This is the aim of the Forum – to bridge the distance and increase the visibility of the relationship between house builders and owners on the one hand, and timber producers, transporters and processors on the other. This is also the reason why the Forum has proposed the logistics stops knowledge level index.

However, large part of timber used in construction of ordinary houses are imported from foreign countries, and in such cases, tracing the route taken by the timber to its place of harvest is difficult. As such, the Forum has provided a list of provisional values to be used in these cases.

4.3. Evaluation of new dwelling houses by the woodmiles index

Fig. 4-1 and 4-2 show the result of case studies, using the woodmiles index for building. Four house constructions with local timber in Gifu Prefecture are analyzed. “Ave.” shows simulation of average house with average timber that is circulated in Japan.

Fig. 4-1 shows Woodmileage for 4 cases. The value of houses with local timber is equal to 1/10th to 1/100th of the average.

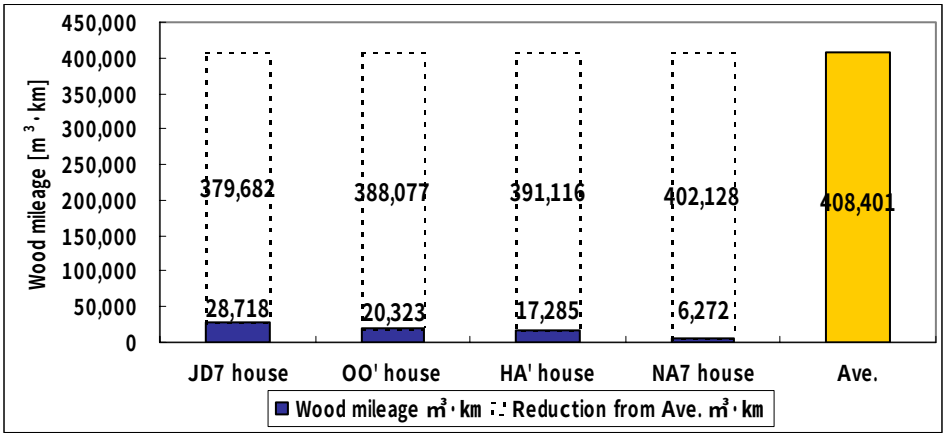

Fig. 4-1 Case study for value of Woodmileage in house construction

Fig. 4-2 shows the values of carbon dioxide from woodmileage for the cases.
The houses with local timber consume from 3000kg to 6000kg less CO_2 than the average house dose.
The Forum is presenting this figure as followings;
The Government of Japan committed in the Kyoto Protocol to a 6% reduction of the amount of discharge of green house gasses as of 1990, in the first commitment period. The amount of $C0_2$ discharged in 1990 from the Japanese households is 129 million tons and 6% of it is 6.6 million ton, while the number of household in Japan is 47 million. Therefore 164kg- CO_2 is the reduction amount for each household equivalent to the Kyoto Protocol commitment. 3000kg to 6000kg – CO_2 is 20-30 times larger than that.

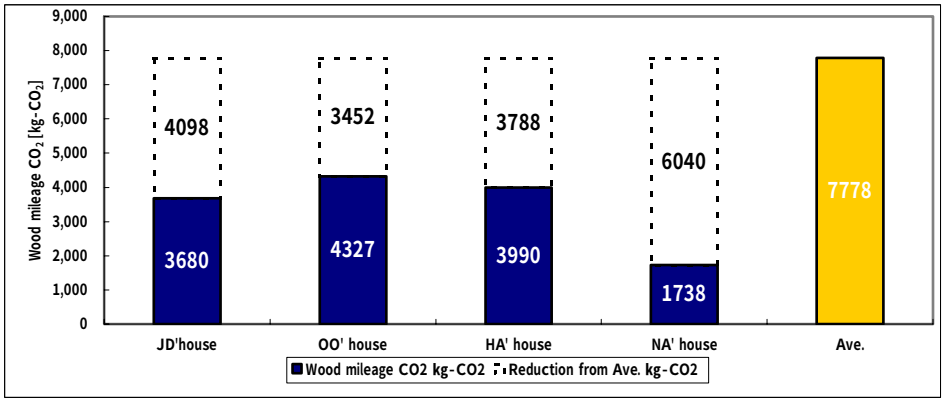

Fig. 4-2 Case study for value of Woodmileage CO_2 in house construction

4.4 The woodmiles index as a tool for business

The woodmiles index for buildings can be a tool used by construction companies and builders, particularly those depending on local timber for their materials, to demonstrate their advantages to their clients. The Forum offers construction companies "the Woodmiles Report Program". The program includes the evaluation of houses built by the clients with the woodmiles indexes, and provision of related data including average values of indexes in Japan and in the region, to compare them with the value of the clients' construction.

If construction companies will seek transparency of distribution of the timber they use, there will be a possibility that members of the timber industry can disclose information on the origins of and routes taken by their products, and provide woodmiles values up to their facilities.

5. Conclusion: the possibilities and the assignments of the woodmiles

It has been two years since the woodmiles movement began in Japan. Though there have not been many applications of the woodmiles indexes, the knowledge on the indexes has spread throughout Japan during that period, in practical, administrative and academic field.

As to the practical or administrative aspect, in the last year, some local authorities have just instituted voluntary system to put labels showing the woodmiles index on building materials. The annual report of forest and forestry (2003) by the Forestry Agency carried an article concerning the Woodmileage in the context of eco-materials.

As to the academic aspect, several studies concerning woodmiles have appeared in the convention of academic societies, including the Japanese Forestry Society, and the Society for Environmental Economics and Policy Studies (SEEPS). One of the studies was distributed by a news agency with national circulation.

In recent years, in Japan, green purchasing activities have been raised in both public and private sectors. It would be getting more important to provide the consumers with reliable information related to the processes of production and transportation of each commodity. The concept of woodmiles would be one of the key words to evaluate the environmental load for building and transparency of the link between the consumers and the forests.

The following themes remain for further studies;
1. From the viewpoint of the environmental loads, we will study a unit of transportation energy that indicates the relation between the transportation distances and the environmental loads.
2. The potential of the woodmiles indexes to include the concepts of some social or cultural aspects other than energy issue, including bio-regionalism etc.

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[1] In recent years, several LCA projects have published their outcome including, the Architectural Institute of Japan, "LCA Guideline of Building", 2003, and the Building Contractors Society, "The report of the activities of LCA Committee", 2003

[2] Office of Public Relation, Cabinet Office of Japan, "The Public-opinion Poll on Forest and Life(2003)"

[3] Nakajima, S. and Okuma, M. "Promotion of Wood Utilization for Mitigation of Global Warming", *Wood Industry*, Vol. 46, 1991 in Japanese

[4] Okuma, M. *"Preservation of Global Environment and Wood Utilization"*, P.71, 2003, in Japanese

[5] In 2003, June, Japan Timber Industry Association run "Forest and Wood Forum – Tomorrow's Life and Wood with the Environment " in Tokyo and Osaka area with over 70 thousand participants.

[6] Forestry Agency, "Annual Report of Forest and Forestry (2003)"

[7] Fujiwara, T. et al, "Energy consumption due to transportation of timber and policy for local timber promotion: policy evaluation with the Woodmileage" in Japanese

[8] The Woodmiles Forum, "CO2 discharged on transportation of timber by origin and production process i" *Woodmiles Study Note #3* in Japanese

[9] Fujiwara, T. "Woodmiles and house constructed with local timber", *Wood Information*, Oct. 2002, Japan Wood Information Center in Japanese

[10] Fujiwara, T. "ditto"

[11] The Woodmiles Forum, "The Goal and Purpose of the Forum" http://woodmiles.net/gaiyou.htm in Japanese