B-51.7 Studies on the Evaluation of Estimation of Anthropogenic Sources and Sinks of Greenhouse Gases

Development of Evaluation Model of Carbon Sequestration in Forest Sector

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ABSTRACT

A computer simulation model developed for the Japanese Forest Resource Basic Plan which is the basis of the Japanese forest policies is utilized to assess mitigation policies under the four scenarios. These are a) stabilizing timber supply at the present level (case 1); b) adopting long rotation (case 2); c) aggressively promoting domestic supply (case 3) and d) moderately promoting domestic supply (case 4). The results indicate case 1 and case 2 contribute to storage carbon into the forest sector, and case 3 contributes to promote the development of the Japanese forest industry. Case 4 compromises both targets.

Newly built floor area in 1996 was divided into wooden and non-wooden structures, and timber input units per floor area were assumed as 0.2m3/m2 for wooden and as 0.04m3/m2 for non-wooden. Then new carbon stock in buildings became 6.52 Mt. Also the lost carbon stock was 1.92 Mt from the data of demolished floor area in 1996. Therefore the increase of building's carbon stock in 1996 was 4.6 Mt, and this amount of carbon was removed from the atmosphere.

Then calculation was done from data in 1997 on carbon quantity which would be input and fixed to construction sector from wood industry. The volume of timber was 24.88 Mm3, calculating from sold amount and processing yield on sawn timber, plywood, and wood composites. This carbon amount was 6.22 Mt, and it was near to 6.52 Mt as mentioned before.

From the data in 1991, wood waste, mainly demolition wood, of 18.23 Mm3 was burnt and buried uselessly, its carbon amount was 4.56 Mt.

Wood composites, particle board etc., has great significance in material recycle of demolition wood. In 1997, used timber ratio as raw material of particle board was 40%, and its ratio is supposed to higher in future.

1.INTRODUCTION

There are several means by which the forest sector are thought to contribute to reduction of global warming and several models has been developed to evaluate these means(Row and Phelps, 1990, Turner et al., 1993). The simulation model for the Japanese Basic Plan is utilized to evaluate some policies mitigating the global warming on this paper. Expansion of forest area is one of those means. Seventy percent of the Japanese topography is mountainous area where are steep slopes and difficult to use there except forests. Because flat plains are limited in Japan, there are few forests in the plains in Japan under high competitions among land uses. Therefore, forests is the dominate land use in the mountains. In stead of that, the possibility that the forest will expand into the plains is extremely small for the foreseeable future. Accordingly, expansion of forest area is not argued here. To lengthen rotation ages of forest stands will realize the increase of growing stock of forest as a measure to mitigate global warming. The trend in recent years among Japanese forest owners is also towards increasing their cutting rotation ages (Japanese Forest Agency, 1994). This tendency has been caused by rising costs of regeneration and tending stands. Thus, the implementation of long rotation policy fits to the recent cutting behaviors of forest owners who have suffered from the high employee wages.

Decreases in the world's tropical forest have become a major problem because of the release of large amounts of carbon dioxide to the atmosphere. Since Japan is the greatest importer of tropical wood in the world, there have been some discussions that Japan should soon reduce importing tropical wood. It has been proposed to decrease the import of tropical wood over the next 10 years. But, a quantitative analysis has not been carried out because this matter is largely a political problem with a lot of uncertainty. Furthermore, there is also an energy problem, because these heavy woods must be transported for long distances (Haynes 1994). This problem is not treated in this paper though it focuses on the reduction of global warming from the perspective of wood supply.

The role of forests for carbon sequestration by accumulation of biomass has been assessed in this paper. After harvesting trees, wood can still fix carbon in the forest sector because felled wood is used as wood products which hold carbon for a long time. Accordingly, extending the durability of wooden houses becomes one of the important means that can mitigate carbon buildup in the atmosphere.

2. SCENARIOS FOR ANALYSIS

Four scenarios are set up to show future wood supply derived from domestic forest resources under different options. Case 1 is a policy that the wood supply will be carried out under stable economic conditions which is similar to the present situation. Japan imports around 79 % of its total demand for wood; which totaled 89 million cubic meters from overseas in 1995. The amount of domestic supply is only 24 million cubic meters. Case 2 scenario almost doubles the rotation length. An average cutting age of Japanese plantations is 56 years old at present. According to the standard yield table for plantations, growth rates of plantations become smaller over 100 years old. Hence, it is not effective to expand the rotation length more than 100 years. Therefore Case 2 scenario is set gradually to postpone a rotation from 55 to 100 years. Other various kinds of suppositions in Case 2 are the same as Case 1. Concretely, the average cutting year is prolonged 10 years for every five years. In Case 3, several positive policies are adopted to expand the domestic supply share in the Japanese timber market. These forest policies include the positive investment for logging roads, introducing highly efficient forestry machines to cut off productive cost, subsidizing forest management and wood industry, adding price competition capability with substitutes of woods and so forth. Given this set of changes, the share of domestic production wood rises from 21 % at the present stage to a share of 32%. Suppositions of Case 4 adopting more moderate comparing to Case 3 and in Case 4, domestic timber will be provided 10% lower than in Case 3.

3. STRUCTURE OF A MODEL and RESULTS

A following model was used for analysis from the above discussion. The model is made up of three submodules which are supply, demand and roundwood market. The supply model differentiate forests into two groups, one active and the other stagnant in management which are called economical timberland and non-economical timberland, respectively (Amano et al,1984). The boundary between two timberland shifts with the fluctuation of timber price, logging cost, logging road construction and so on. A simple equation to determine the area of timber land A_{timber} at a planning period t is derived by total plantation area A_p, timber price p(t), harvesting cost c(t), and new logging road construction mileage l(t).

$$A_{timber}(t) = f(A_p, p(t), c(t), l(t))$$

This boundary is considered as the factor to determine the portion of economical timberland in the total forested area. Currently the economical timberland is the primary source of domestic timber supply and amount of this supply in the sum of products of harvesting probabilities (Suzuki, 1984) and the corresponding forest area. This probability was developed for predicting the timber supply using the Markov Process with age transition matrix R and forest area A_t at a planning period t.

$$A_{t+1} = A_t P$$

where

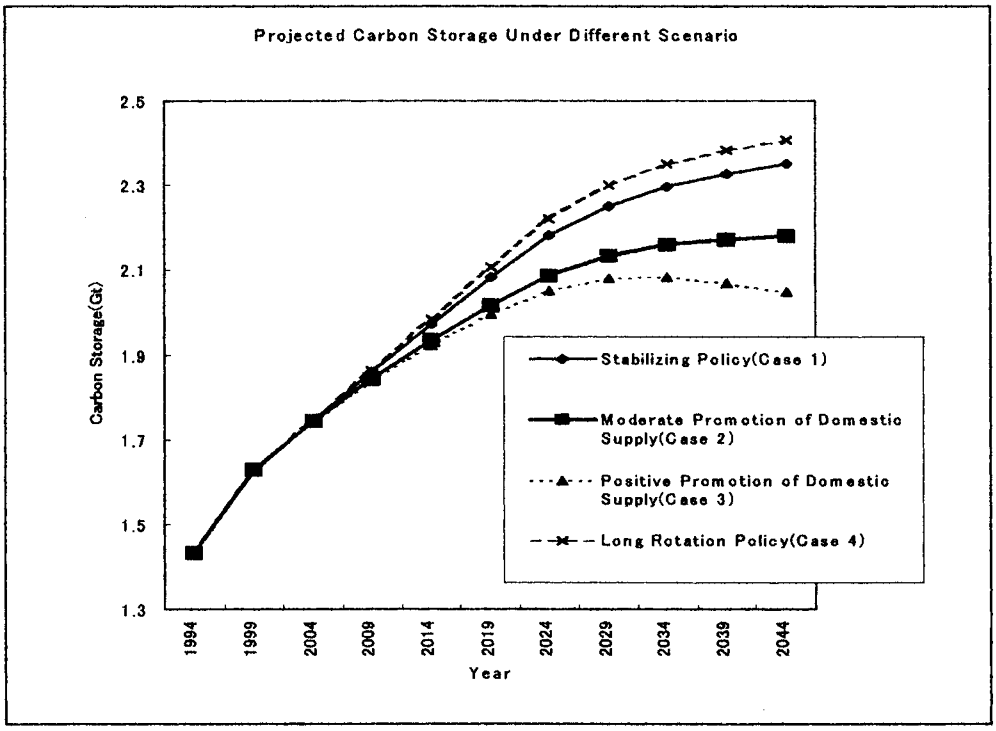
$$A_t = (a(t)_0, a(t)_1, \ldots, a(t)_i, \ldots, a(t)_n)$$

$$R = (r(j,k)), \quad j,k = 1,2,\ldots,n$$

$a(t)_i$ is the forest area of i-th age class and r(j,k) is the transition probability from j-th age class to k-th age class. The forecasting parameters of harvesting probabilities are derived from a mean cutting age and its variance(Suzuki, 1984) . So it is easy to reflect the changes of cutting rotations length.

Demands for sawnwood, panelwood, and other uses including pulpwood were estimated by the demand submodule made by ordinary econometric models(Amano and Noda, 1987). The demand and the supply submodules are linked through the roundwood market submodule. Demand and supply equilibria are computed for 5-year periods over the projection period. It is difficult to determine an equilibrium point at the quantities of demand and supply. In the model, feedback iterations proceed in the three submodules until the demand and supply volumes converge upon an equilibrium.

As shown Figure, the total carbon included in the forest sector in 50 years later shows the long rotation scenario is the best among four scenarios. Extension of a rotation itself did not give great influence to increase of growing stock in a country with much import wood like Japan. Also harvesting volume in Case 2, 1,47 million m^3 is not differed from Case 1, 1.55 million m^3. By a scenario given as Case 3, forests will provide 40 million m^3 in 2015 which is 65% greater than present supply. But as shown in Figure, future carbon stock within the forest sector will decrease in Case 3. This phenomenon is not suitable for the mitigation of global warming. It seems that political efforts are not important to prolong rotation length, because forest owners can not find out enough timber market at the present timber price and will keep their forests without cutting incentives. On this account, the extension of rotation is realized without a severe policy effort in Japan. However domestic timber supply will fall down to around 60% comparing the amount of present supply. The scenario of moderate promoting domestic timber supply, Case 4, will product timber 38% greater than present supply. On the other hand, future carbon stock in the forest sector will continuously increase.



4. Evaluation of Carbon Sequestration in Wood Utilization Sector

(1) Significance of wood utilization on global warming

It is the one of the biggest problems in coming century that the climate change such as global warming caused by rapid increase in the concentration of the carbon dioxide and other gases in our atmosphere in this century.

To reduce the fossil fuel consumption by several percents may decrease just the ratio of increase in carbon dioxide slightly. It is the most effective and practical option to use the function that trees continue absorbing and fixing the carbon dioxide into their trunk throughout their lives, if using the function, the carbon dioxide will be eliminated from our atmosphere remarkably. In other words, reforestation of the deserted land, or recovering the stock of the degraded forest will decrease the concentration of the carbon dioxide significantly.

A large amount of carbon dioxide is absorbed in the forests when the trees are young. However, the gross primary production by photosynthesis becomes constant in matured or aged forest by quantity of daylight, while the net primary production is decreased because of the increase of woody respiration by grown trees. Finally, the net increment in the forest approximates to none, adding the emission of the carbon dioxide from dead trees and so on. This means that although huge amount of carbon is fixed in the trees or soil, there is no absorption nor emission of the carbon dioxide in such kind of forest apparently. Almost all of the neglected natural forests are thought to be in this condition.

Therefore, in order to use the effect of reducing the carbon dioxide prepared in the forests, it is necessary to keep the net increment of the forest plus by harvesting the matured of aged trees appropriately. One of the role of the wood utilization is to be the base of sustainable forest management and to give it the economic foundation. Furthermore, the afforestation mentioned above naturally needs investment. The utilization of timber when the forests are matured brings the economic motivation and the incentive for afforestation.

(2) Significance of long-lived wood utilization

In the secondary report of IPCC, the effects of the wood utilization for the reduction of the carbon dioxide are tabulated as follows:

1. The stock of the carbon dioxide by preservation and using wood and wood products (Stock effect).
2. The reduction of carbon emission by replacing non-wooden materials that are energy intensive type (Energy saving effect).
3. Continuing isolating the carbon in the fossil fuel or non-releasing the carbon from the

fossil fuel by replacing the fossil fuel (Energy replacing effect).

At COP3, it became the duty of Japan to reduce the gases that bring the global warming such as the carbon dioxide by 6 % to the emission level of 1990 in 2010.

Among the effects mentioned above, the energy saving effect in No. 2 and the energy replacing effect in No. 3 directly relate to the reduction of the emission of the carbon dioxide from the fossil fuel in Japan by, for example, substituting non-wooden building materials into wood products or by the energy recycling of demolition wood. Hence, we have already had several conditions that can become the incentive to encourage wood utilization.

However, it is questionable that these obtain the consensus of Japanese people today. And in the present state of affairs, there are not any politic movements in order to promote No. 2 and No. 3, for there are some problems such as the serious Heisei recession or dioxisine from incinerators. According to our trial calculation, both No. 2 and No. 3 possibly decrease the carbon dioxide by about 1 % each to the total emission, though further data are not shown in this report because the objective of this report is not showing such data.

On the stock effect in No.1, no concrete discussions were made even at COP3 nor COP4 while the discussions on the estimation of long-lived wood utilization were made at IPCC expert meeting in 1998 and others. Discussions will be made in SBSTA for the next COP5 in earnest.

The evaluation methods discussed at present are as follows:

1. 1996 IPCC default approach
2. Atmospheric-flow approach
3. Stock-change approach
4. Production approach

Here, each approach is explained shortly. In every method, the carbon is supposed to be absorbed when the stock in the forests increases. That is to say, the sustainable forestry would not cause the carbon emission.

In the default approach of No. 1, the timber harvested is not taken into account assuming that the variation of the stock in a short period can be neglected even if there are various flows. The carbon emission by harvested timber is supposed to be done in the producing country.

The flow approach of No. 2 is equivalent to dealing with the fossil fuel, and the carbon emission by harvested timber is assumed to be done in the country where the timber are used.

In the stock approach of No. 3, the important matter is where the carbon stock exists. The quantity of the carbon is none when the harvested timber is in the producing country and it is considered that the carbon is emitted if the timber is disused or exported. In the timber importing countries, the carbon is thought to be absorbed if the stock is increased and to be none when timber is disused.

In the production approach of No. 4, the change of the carbon stock is assigned to the producing country, and the exported timber is interpreted as the carbon emission of the producing country when the timber is discarded in the importing country.

In selecting these approaches, firstly, it is prerequisite condition whether the approach reflects the global carbon flow exactly or not. From this point of view, the default approach is not suitable as mentioned later.

Next, the approach that gives deforestation the minus incentive is preferable. Although the incentive is minus in most of the approaches when the timber is consumed in producing country, the incentive is zero in the flow approach when the timber is exported, and this is the problem.

The plus incentive would be needed for the long-lived wood utilization. In the case of using timber produced by the sustainable forestry, the incentive is plus in all approaches without the default approach. But when the imported timber is used, the incentive is zero or minus in the approaches except stock approach if the processing yield is taken into account.

In the countries that have the potential to produce timber more than the demand in the countries themselves, there would be the opinion that changing the neglected forests into the sustainable forestry and exporting more timber is better because the total absorbed carbon dioxide increases. If thinking so, the incentive is large in the case of the flow approach and it becomes plus in the production approach when the timber importing countries use wood as long-lived products.

Here, what has to be noticed is that the carbon stock in the forests where the sustainable forestry is done is less than that in the forests which is mainly composed of matured or aged trees with the same area as the former forests because there are a lot of juvenile trees. Our test calculation indicates that the total of the fixed carbon is less than that in the neglected forests unless the wood is utilized for at least years needed to reach the felling years.

The most preferable evaluation method for Japan is considered. First of all, the flow approach is never accepted by our country that imports a large amount of timber. The default approach is not adequate because the plus incentive is not appeared to promote wood utilization. Even the production approach does not have any merits in using the imported timber. Hence, the stock approach is the most appropriate.

It is significantly important to understand and predict precisely the carbon flow and stock by wood utilization in our country even if any evaluation methods are adopted internationally. The objective of this work is to calculate the flow and stock and to clarify the problems about them at present.

(3) The present state of wood utilization in our country

The amounts of the carbon flow and the carbon stock should be understood based on the data of wood demand in our country. Then, the wood demand from 1949 to 1997 is shown in a figure and a table.

These data indicate the uses of the newly harvested timber from the forests in our country or in exporting countries in Japan each year. Hence, the collection of used paper or recycling of wood from demolished buildings are not included. The total flow in our country should contain them.

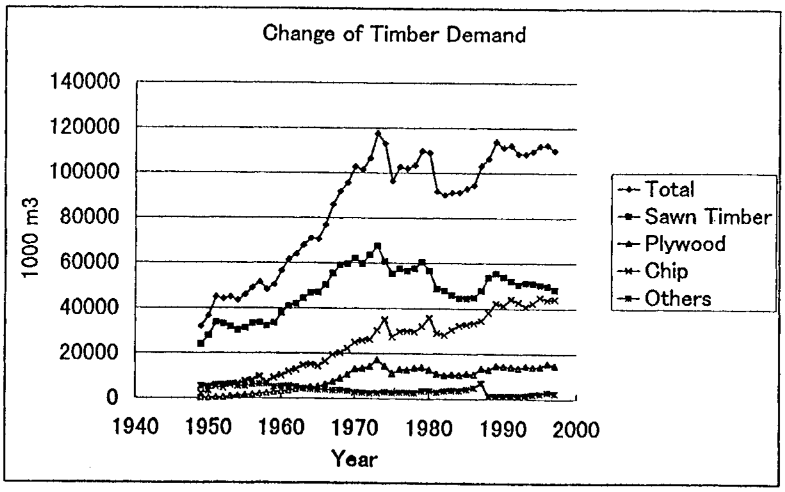
It is also notable that these data are based on log volume. This means that the imported logs into factories in our county become just the domestic flow while a part of the carbon included in the wood imported as manufactured goods or semi-manufactured ones exists in the exporting countries because the quantity of the carbon is inverted into the log volume a constant yield. In the case of the sawn timber or pulp which the quantity of the import is increasing intensely in recent years, such attention is needed.

These are the figures for industrial round wood, and then the quantities of firewood and wood for shiitake (mushroom) cultivation are not included. These woods account for about 2 % of the recent total demand.

Our country is a huge wood consuming one which uses over

Timber Demand (Unit : 1000m3、Log base)

Year	Total	Sawn Timber	Plywood	Chip	Others
1949	31885	23970	258	2207	5450
1950	36564	27806	298	3284	5176
1951	44876	33563	468	4996	5849
1952	44016	32957	525	4547	5987
1953	44849	31737	881	5938	6293
1954	43468	30290	1149	6615	5414
1955	45964	31262	1492	7757	5453
1956	49144	33229	1737	8146	6032
1957	51444	33433	2060	9642	6309
1958	48303	32171	2392	7364	6376
1959	50593	33474	2826	9162	5131
1960	56547	37789	3178	10189	5391
1961	61565	40891	3365	11834	5475
1962	63956	41964	4090	12805	5079
1963	67761	44424	4352	14615	4370
1964	70828	46751	4943	15053	4080
1965	70530	47084	5187	14335	3924
1966	76876	50373	6257	16375	3871
1967	85947	55398	7476	19376	3698
1968	91806	58981	8912	20225	3688
1969	95570	59534	10597	22122	3317
1970	102679	62009	13059	24887	2724
1971	101405	59801	13362	25715	2527
1972	106504	63613	14309	26202	2380
1973	117580	67470	17151	30414	2545
1974	113040	60734	14481	34957	2868
1975	96369	55341	11173	27298	2557
1976	102609	57394	12939	29639	2637
1977	101854	56564	12717	29841	2732
1978	103417	57560	13585	29597	2675
1979	109786	60314	13915	32137	3420
1980	108964	56713	12840	35868	3543
1981	91829	48718	11086	29056	2969
1982	90157	47862	10499	28279	3517
1983	91161	45990	10849	30584	3738
1984	91361	44518	10664	32433	3746
1985	92901	44539	11217	32915	4230
1986	94506	44933	10942	33558	5073
1987	103136	47937	13463	34671	7065
1988	106282	53681	13020	38265	1316
1989	113850	55481	14703	42313	1353
1990	111160	53887	14546	41344	1383
1991	112166	52230	14216	44245	1475
1992	108489	50551	13800	42760	1378
1993	108265	51159	14533	40894	1679
1994	109500	51001	14099	42375	2025
1995	111930	50384	14314	44931	2301
1996	112325	49758	15726	43822	3018
1997	110010	48415	14816	44229	2550

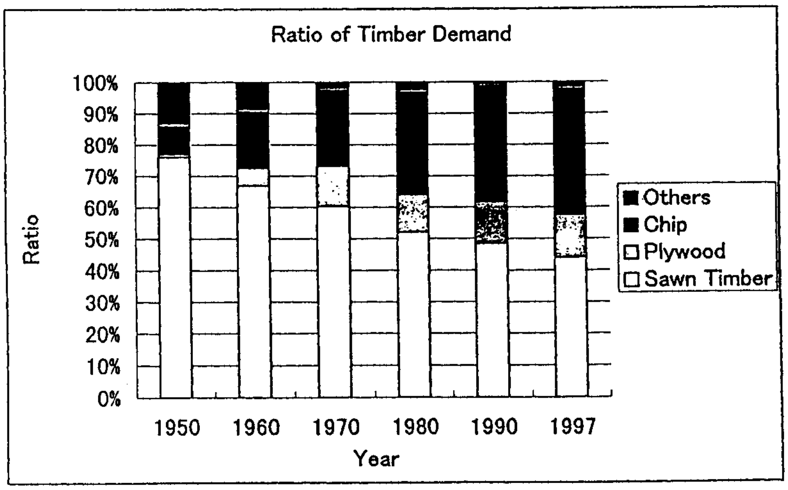


100 Mm3 of wood a year after 1987. And our country imports the most wood in the world from the view point of wood trading. However, the consumption of wood per one person may not be so large thinking that the consumption in Japan is 1 m3 compared to 2.4 m3 in U.S.A..

The total demand had increased with the economic development after the World War II and reached the maximum value of 120 Mm3 in 1972 and the keynote of increasing changed with worse business caused by the first energy crisis. Though the total demand remains more than 100 Mm3 because of the policy of the expansion of the domestic demand, it will be below 100 Mm3 in 1998 by the Heisei recession.

Looking at the demand from the angle of each use of wood, the wood for the chip for paper making is not subject to the change of business and remains the increasing tendency, for paper is a kind of the necessities of life. On the other hand, the wood for sawn timber, 80 % of which is used for building, is influenced by the times and tends to decrease. Since the condition that the stock of houses is larger than the number of households continues, the demand for rebuilding which is not so hasty is thought to be sensitive to business. Although the movement of plywood is similar to that of the sawn timber, as a whole, its movement has an increasing tendency because the ratio of 2 by 4 construction becomes larger than that of Japanese traditional style one due to the change of the way to build a house.

Investigating this demand for each use through long years, the wood for sawn timber which was near to 80 % in 1950 decreased with years and approximated to 40 % in 1997. On the other hand, the wood for chip had come up from a little under 10 % to 40 %. It is found that the ratio of the wood for plywood had also increased largely by 1970.



Here, among the wood for chip, the type which is made from the unused part of logs such as slab or left pith is not included in the figures because they are counted among the wood for sawn timber or plywood. Their ratio is about 15 % to the wood for chip, and if they are contained, the ratio of the wood for chip becomes the largest in wood demand.

On the other hand, taking notices of wood supply, the domestic one is 20 % and then the imported wood is 80 % in 1996. The ratio of the self-support of wood has kept decreasing recently. Going into detail about this tendency, it owes to the fact that the supply of the hardwood for pulp chip mainly has decreased. The decrease of the softwood which is mostly used for sawn timber is not so large.

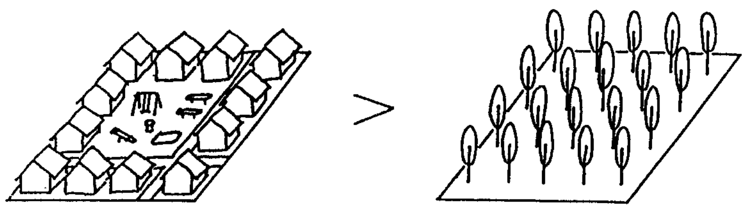
Estimating the variation of the domestic carbon stock using the flow approach or the production approach is probably difficult from the imperfections of statistic data, from requiring a lot of labor, or from accuracy of estimation, because domestic timber and imported timber must strictly be divided.

(4) Carbon stock by long-lived wood products

Firstly, the test calculation of the carbon stock by building a wooden house is shown as an example of the long-lived wood products.

Carbon Stock in Area with Wooden Houses

Number of Houses		Floor Area		Timber Input Unit		Timber's Carbon		Carbon Stock
60houses/ha	×	100m2/house	×	0.2m3/m2	×	0.25t-C/m3	=	300t-C/ha



The total residential area is 6000 m2 if the land area is 1 ha and the area of road, a park and a green land are 40 %. Suppose that the area for a house is 100 m2, then 60 houses can be built there. A wooden house is two storied whose total floor area is 100 m2. On the quantity of wood used for a wooden house, in this report, 0.2 m3 for 1 m2 of floorage is adopted. If the oven dried specific gravity is 0.5, the quantity of the carbon equals to 0.25 ton per 1 m3 because the ratio of the carbon is 50 % in weight. Calculating from these data, 300 tons of carbon is fixed on the 1 ha land in wooden houses, and the quantity is much more than the carbon per ha fixed in the biomass in forests and soil in Japan. Taking into account the fact that the carbon is fixed in soil of the residential land, figures will enlarge more.

If this timber used for building is produced by the sustainable forestry, the carbon absorption more than the harvested quantity can be done in the forest.

Accordingly, this indicates the appearance of the new forest in a city. It is understood that the increasing wooden houses have an important sense in the view point of carbon sequestration in the case of our country in which there is little space for afforestation.

Several problems in this trial calculation are shown as follows.

Though the value of 0.5 is used as the specific gravity of wood, that of the wood species of a column and others is from about 0.4 to about 0.6. But the specific gravity of the domestic sugi wood (Japanese cedar) is often less than 0.4, and it will be necessary to examine the variation of the specific gravity and the ratio of the domestic wood and the imported one used for building. In addition, in the case of wooden materials, the specific gravity of the plywood used for building construction such as walls is about 0.6 and that of the particleboard used as material under floor is about 0.7, and the used ratio of each material is also a problem.

Although many researchers regard the carbon content of wood as 50 %, that of many kinds of wooden board is estimated to be 45 %, and then, errors in calculation are caused.

The biggest problem is the timber input unit of wood utilization per the building area, and this is explained fully in the next section.

1) Timber input unit in building

There are various data studied on the timber input unit, the quantity of wood utilized in unit area of a building. Among the timber input unit for residential building, there is a difference between a detached house and an apartment house, while various uses such as offices, stores, mills, warehouses, schools, and hospitals exist in the unit for non-residences. Looking at each building from the view point of structures, suchlike steel reinforced concrete (SRC) structure, reinforced concrete (RC), and steel (S) are complexed.

Several examples are shown from the collected results.

Investigation of Timber Input Unit by Japan Timber Information Center in 1987

	Residential Wooden Traditional	2 by 4		Pre-Fab.		Steel Pre-Fab.	
	Apartment	Detached	Apartment	Detached	Apartment	Detached	Apartment
No.	18	15	7	3	3	7	6
Average Floor Area m2	209.8	149.3	193	127	197.2	119.1	213.7
Sawn Timber m3/m2	0.126	0.169	0.163	0.115	0.118	0.062	0.053
Laminated Timber m3/m2	0.001	0.004	0.002	0.001	0.001	0.001	0.001
Plywood etc. m3/m2	0.016	0.048	0.046	0.037	0.055	0.021	0.012
Total Input m3/m2	0.143	0.221	0.211	0.153	0.174	0.084	0.066

	Non-Residential Wooden						Non-Wooden				
	Warehouse	Mill	Office	Hotel	Shop	School	School	Office	Hotel	Shop	Mill
No.	3	3	4	3	3	4	3	2	2	2	2
Average Floor Area m2	48.3	513.7	692.3	575.3	155.2	1153.1	11418	1320.7	2472.5	106.3	2731
Sawn Timber m3/m2	0.101	0.158	0.144	0.205	0.122	0.251	0.003	0.027	0.022	0.006	0
Laminated Timber m3/m2	0	0	0	0	0	0.003	0.001	0	0	0.008	0
Plywood etc. m3/m2	0	0	0.053	0.011	0.004	0.001	0	0	0.005	0.014	0
Total Input m3/m2	0.101	0.158	0.197	0.216	0.126	0.255	0.004	0.027	0.027	0.028	0

	Residential Concrete Pre-Fab.		RC, SRC Traditional			Steel Traditional	
	Detached	Apartment	Detached	Apartment for Sale	Apartment for Rent	Detached	Apartment
No.	3	3	5	13	12	9	10
Average Floor Area m2	121.1	515.3	285.2	8612.2	6299.7	170.2	405.8
Sawn Timber m3/m2	0.048	0.033	0.032	0.022	0.014	0.048	0.038
Laminated Timber m3/m2	0.003	0	0.001	0.001	0.002	0.002	0.001
Plywood etc. m3/m2	0.008	0.015	0.005	0.002	0.005	0.014	0.009
Total Input m3/m2	0.059	0.048	0.037	0.025	0.02	0.063	0.048

Investigation of Timber Input Unit into Houses (Unit: m3/m2)

Structure	Sawn Timber	Laminated Timber	Wooden Board	Total
Wooden Traditional	0.163	0.015	0.021	0.199
Two by Four	0.153	0.013	0.038	0.205
Steel	0.038	0.007	0.024	0.069
Concrete	0.053	0.004	0.008	0.064

Investigation of Timber Input Unit by Ministry of Construction in 1989 (Unit: m3/m2)

	Structure	Wooden	SRC	RC	S	CB	Others
Residential	Sawn Timber	0.1632	0.0235	0.0299	0.0374	0.0572	0.0469
	Plywood	0.0146	0.0164	0.0208	0.0072	0.0205	0.0137
Residential and	Sawn Timber	0.185	0.0194	0.028	0.0333	0.0452	0.0233
Industrial	Plywood	0.0177	0.0174	0.0198	0.0072	0.001	0.0105
Office	Sawn Timber	0.162	0.0058	0.0177	0.0077	0.0344	0.0189
	Plywood	0.0167	0.0131	0.0161	0.004	0.0089	0.0095
Shop	Sawn Timber	0.1609	0.0099	0.0079	0.0099	0.0062	0.0491
	Plywood	0.0185	0.0122	0.0135	0.005	0.0083	0.0189
Mill	Sawn Timber	0.1473	0.0056	0.0081	0.0044	0.0068	0.0104
	Plywood	0.0115	0.0013	0.0147	0.0033	0.0066	0.0095
Warehouse	Sawn Timber	0.1302	0.06	0.0086	0.0065	0.0053	0.0043
	Plywood	0.0122	0.0143	0.0174	0.0032	0.0008	0.0106
School	Sawn Timber	0.1876	0.0135	0.0147	0.0164	0.0376	0.059
	Plywood	0.0214	0.0635	0.0191	0.0088	0.0193	0.0094
Hospital	Sawn Timber	0.1857	0.0338	0.0103	0.015	0.0405	0.0394
	Plywood	0.0249	0.013	0.0162	0.0071	0.016	0.009
Others	Sawn Timber	0.1866	0.013	0.02	0.0105	0.0231	0.0086
	Plywood	0.0152	0.0147	0.0185	0.0058	0.0166	0.006

According to the investigation of the data by dividing them into the wooden structure and non-wooden one broadly, it is found that there are large variations of 0.101 - 0.221 m3/m2 in wooden construction and 0 - 0.084 m3/m2 in non-wooden one.

In the example of the non-wooden apartment houses, several researches result in that the timber input unit tends to decrease if the years when they were built are young.

Timber Input Unit into Non-Wooden Apartment House
(Non Official)

Years	Backing m3	Decoratives m3	Wooden Board m3	Total m3	Ave. Floor Area m2	Unit Input m3/m2
1975-	2.062	0.523	0.716	3.301	60	0.055
1980-	1.897	0.465	0.744	3.106	65	0.0478
1985-	1.504	0.399	0.771	2.674	70	0.0382
1990-	1.713	0.381	0.433	2.527	80	0.0316
1995-	1.503	0.381	0.433	2.317	70	0.0331

Timber Input Unit into Non-Wooden Apartment House
(Japan Housing Corporation)

Years	Backing m3	Decoratives m3	Wooden Board m3	Total m3	Ave. Floor Area m2	Unit Input m3/m2
1975-	2.53	0.721	1.855	5.106	65	0.0786
1980-	2.46	0.71	1.855	5.025	65	0.0773
1985-	3.12	0.622	2.008	5.75	70	0.0821
1990-	2.213	0.563	2.008	4.784	70	0.0683
1995-	1.79	0.509	2.008	4.307	70	0.0615

In the case of wooden houses, the timber input unit may change with the revision of the standard for earthquake-resistance in the law for the building standard.

In this report, 0.2 m3/m2 for wooden buildings and 0.04 m3/m2 for non-wooden ones are adopted as the timer input units.

From the research results, there is a tendency that the timber input unit is large in residential buildings and small in non-residential ones. The influence is regarded as light in the case of the data on the non-residential buildings in which wood utilization is small because the 90% of wooden buildings are for residential exclusively. On the contrary, though there are some research results which show the timber input unit is beyond 0.04 m3/m2 in the non-wooden buildings of residential use or residential and industrial use, it is thought that accounting for 50% of non-residential buildings decreased the average.

2) Carbon stock in construction sector

In order to know the quantity of the carbon stocked by fixing wood into buildings, the statistics on the number of newly built constructions is needed. Then, the quantity of newly built constructions is shown to each structure from 1951 to 1996.

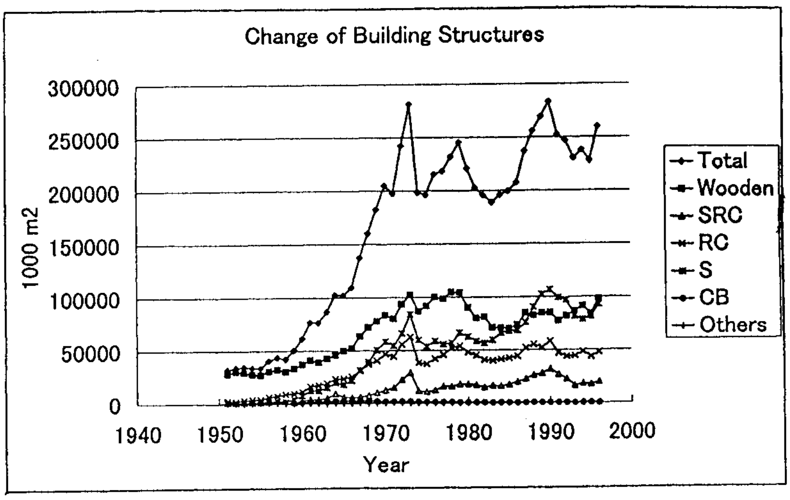
It is said that the ratio of the investment to buildings is much larger in our country than western countries. Moreover, houses are rebuilt in much shorter period such as from 1/2 to 1/4 of western countries. This does not mean that buildings can not endure for a long time, and this tendency is thought to be because of the problems of social system. Nowadays, a counter measure not to decrease the building flow is undertaken in order to get over the serious Heisei recession. However, the environmental problem of the earth will need to change the flow-type construction into the stock-type one. Hence, the number of newly built constructions will decrease gradually.

On the number of newly built constructions, there was a constituent tendency of increasing after the World War II, but the tendency of the sharp decrease occurred in 1974 by the first energy crisis. And then, though there are some variations, the number is more than 200 Mm2 after 1986.

Building Structures (Unit : 1000m2)

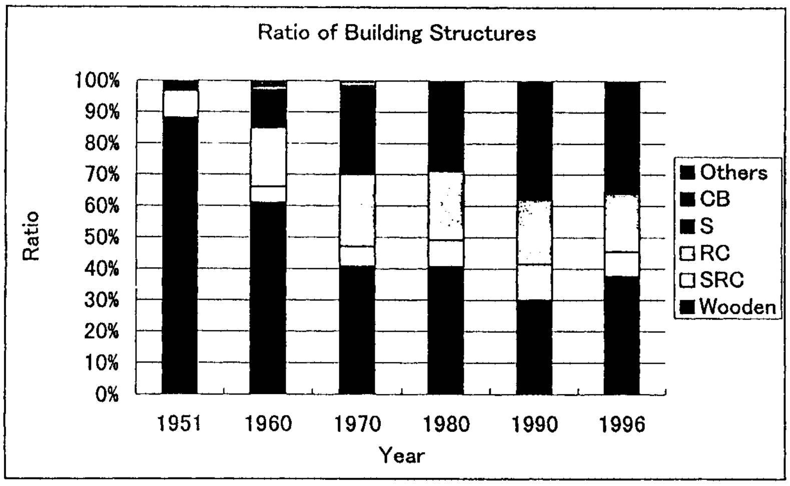
Year	Total	Wooden	SRC	RC	S	CB	Others
1951	32450	28624		2751	942		134
1952	34356	30914		2326	853		262
1953	35121	29911		3506	1338		366
1954	34106	28318		4078	1179		532
1955	33920	27684		4318	1274		645
1956	40866	31289		6513	2226		837
1957	43669	32533		7546	2604		985
1958	42429	30726		9033	2312		358
1959	50766	33622	1704	9777	4374	1113	175
1960	61461	37547	3047	11558	7568	1485	257
1961	76872	41384	4165	16560	12438	1926	400
1962	76645	39408	4232	17897	12442	2182	484
1963	86835	43156	5522	19699	15406	2522	531
1964	102663	46167	9543	23616	19931	2774	633
1965	102300	50149	6380	23970	18374	2913	515
1966	109737	52570	5904	25822	22147	2749	544
1967	137398	63762	6505	31378	32265	2805	682
1968	160470	72296	7914	37235	39613	2921	491
1969	182748	77792	10409	40739	50713	2699	396
1970	205034	83747	12860	46882	58534	2451	560
1971	197737	80202	15210	44627	54699	2195	803
1972	242309	93831	23046	55893	66233	2341	965
1973	281751	102681	29491	62726	84147	2373	332
1974	198557	87047	12096	38652	59804	1776	181
1975	196292	91916	11087	37624	53749	1607	309
1976	215474	100438	12650	42081	58675	1435	195
1977	218509	98819	16379	45897	55858	1322	234
1978	231997	104938	16346	52185	56920	1398	210
1979	245299	104874	18333	54081	66625	1100	285
1980	220973	90301	18383	48355	62710	990	233
1981	202714	80290	17505	45266	58511	875	267
1982	195642	81384	15226	41213	56672	806	341
1983	189281	71526	16960	40375	59475	663	282
1984	196138	70970	16307	41817	66071	618	335
1985	199560	70493	17748	42571	67926	528	293
1986	207682	73679	20316	44339	68520	515	314
1987	237226	85081	23168	52057	76087	498	336
1988	255783	82726	26547	55106	90580	481	343
1989	269210	85094	28240	52384	102643	461	288
1990	283421	85397	32288	58061	106841	460	374
1991	252260	77507	27108	47248	99570	377	449
1992	246601	82059	22872	43896	97092	314	370
1993	230654	86748	16674	44706	81805	284	436
1994	238066	91450	18619	48440	78815	231	511
1995	228145	84167	17775	43847	81575	351	431
1996	259793	98127	20168	47807	92906	268	518

Investigating the details about each building through years indicates that the ratio of wooden buildings approached to 90 % in 1951, decreased with years to 30 % in 1990, and reached about 40 % in 1996. The ratio of other structures, especially that of S-structure, increased remarkably. In around 1990, the more S-structures than wooden ones were built.



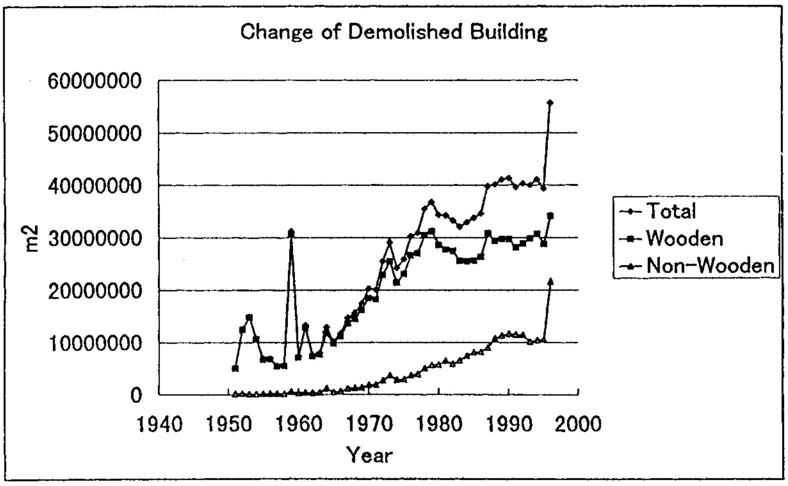
Multiplying these figures by the timber input units mentioned above enables to assume the quantity of the new carbon stock each year.

On the other hand, the loss from the stock must be also obtained in order to understand the stock change in every year.



And then, the quantity of demolished buildings by replacing for suchlike rebuilding and the loss by disasters from 1951 to 1996 is shown in a figure and a table.

On this data, there are not the statistics about each structure like newly built constructions but only the values of wooden buildings and non-wooden ones.



In the change in demolished buildings, though there is a slight effect on business trend which is different from newly built constructions, the number of demolished buildings has a near-consistent rising tendency. This can be understood by recognizing that the buildings whose number increased till 1973 are removed. In addition, the sudden increase in demolished buildings in 1959 is almost due to disasters, that is to say, the nation-wide damage by Ise-wan typhoon in the year.

Investigating details about each structure in demolished buildings, though most of such buildings are wooden ones till 1960, demolition of non-wooden buildings increases gradually, and about 40 % of demolished buildings is composed of non-wooden ones in 1996. Hereafter, the ratio of non-wooden buildings is thought to increase, because the constructions which were built when the ratio of wooden constructions among the newly built constructions build decreased, will be replaced.

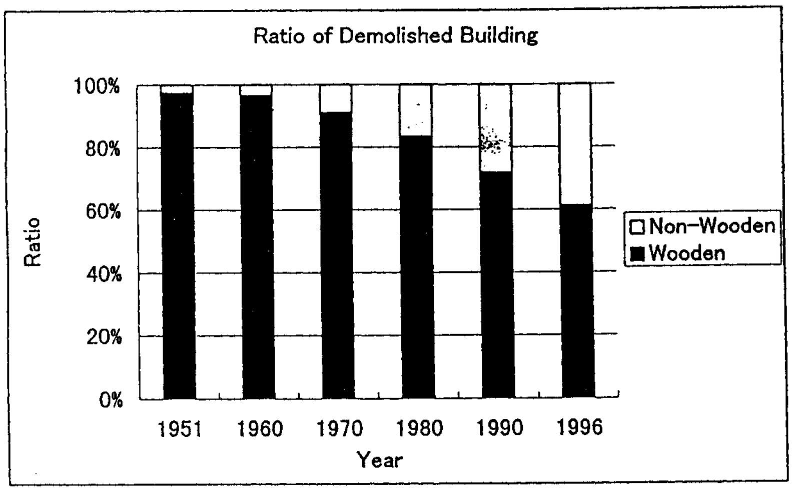
Using the same method mentioned above, by multiplying each value by the timber input units, the carbon loss from the stock of buildings can be estimated.

Here, test calculation is carried out on the increase in the carbon fixed into buildings in our country in 1996.

Demolished Buildings (Unite：m2)

Year	Total	Wooden	Non-Wooden
1951	5087276	4954917	132360
1952	12578567	12410776	167791
1953	14876222	14773912	102310
1954	10733834	10631683	102151
1955	6776309	6643250	133059
1956	6854872	6703432	151440
1957	5526085	5362863	163221
1958	5579931	5454444	125486
1959	31201397	30643327	558070
1960	7259083	7014205	244878
1961	13234885	12841409	393476
1962	7654922	7334334	320588
1963	7953527	7597918	355249
1964	12910807	11747740	1163067
1965	10262521	9794852	467669
1966	11818685	11167756	650929
1967	14717674	13602666	1115008
1968	15698231	14465992	1232239
1969	17511922	16170718	1341204
1970	20273653	18461699	1811954
1971	20061973	18223883	1838090
1972	25502618	22859053	2643565
1973	29078345	25451042	3627303
1974	24227636	21437836	2789800
1975	25938284	23081206	2857078
1976	30255221	26622340	3632881
1977	30897577	27033024	3864553
1978	35444616	30488479	4955537
1979	36719284	31158762	5560522
1980	34278601	28579745	5698856
1981	34163331	27734299	6429032
1982	33244669	27438641	5806028
1983	32045718	25570422	6475296
1984	32869614	25425148	7444466
1985	33697059	25616984	8080075
1986	34533047	26334773	8198274
1987	39731278	30748014	8983264
1988	40104738	29377689	10727049
1989	41021057	29720290	11300767
1990	41310460	29668151	11642309
1991	39564753	28087233	11477520
1992	40275378	28815351	11460027
1993	39970408	29818092	10152316
1994	41041544	30625741	10415803
1995	39284254	28731860	10552394
1996	55642536	34053393	21589143

The effective figures of the timber input unit is only about 1 place at present, and there are problems about the carbon in wood as mentioned above, too. Accordingly, although the exact confidence of the calculated results is about 1 place, figures in 10 thousand ton are shown so as to indicate a rough image.



In the newly built constructions, the carbon fixed in wooden buildings is 4.91 million ton and that fixed in the non-wooden ones is 1.62 million ton. The total fixed carbon added to the whole Japanese construction stock by the newly built ones is estimated to be 6.52 million ton using rounding off. The carbon in demolished buildings becomes 1.7 million ton for wooden buildings and 220 thousand ton for non-wooden ones from the same calculation procedure. The loss of the construction stock is 1.92 million ton. Subtracting the loss from the added carbon makes the 4.6 million tons of increase in the fixed carbon, and if wood used in the construction is obtained by the sustainable forestry, this amount of carbon is eliminated actively from our atmosphere.

Calculation on Increase of Carbon Stock in Buildings in 1996

Carbon Stock in New Buildings

Wooden Newly Built Area		Timber Input Unit		Timber's Carbon		Carbon Stock
98,127,000m2	×	0.2m3/m2	×	0.25t-C/m3	≒	4.91Mt-C

Non-Wooden Newly Built Area		Timber Input Unit		Timber's Carbon		Carbon Stock
161,667,000m2	×	0.04m3/m2	×	0.25t-C/m3	≒	1.62Mt-C

Total Carbon Stock in New Buildings 6.52Mt-C

Carbon Stock in Demolished Buildings

Wooden Demolished Area		Timber Input Unit		Timber's Carbon		Carbon Stock
34,053,393m2	×	0.2m3/m2	×	0.25t-C/m3	≒	1.70Mt-C

Non-Wooden Demolished Area		Timber Input Unit		Timber's Carbon		Carbon Stock
21,589,143m2	×	0.04m3/m2	×	0.25t-C/m3	≒	0.22Mt-C

Total Carbon Stock in Demolished Buildings 1.92Mt-C

Increase of Carbon Stock in Buildings 4.60Mt-C

3) Quantity of the wood injected into construction sector

According to the test calculation in the last section, the rough quantity of the carbon stock is obtained, but there is a problem about such as the timber input units. Then, the quantity injected into construction sector from the wood industry side is assumed and the more investigation is made.

Here, the data in 1997 are adopted because the quantity of plywood production was recorded from in square to in volume in that year, so the conversion to carbon became easy. Compared to 1996, the total timber demand reduced by 2 %.

Calculation on Timber Input as Construction Materials

Sawn Timber(1997)

Domestic Products Raw Materials 33.15Mm3 Production 21.95Mm3
Imported 12.19Mm3 Total 34.14Mm3
Construction Use 80%→×0.8=27.31Mm3
Processing Yield 80%→×0.8=21.83Mm3

Plywood(1997)

Production 9.55Mm3(Domestic・Imported)
Construction Use 50% For Concrete Works Assumed 30%
→×0.2 =1.91Mm3

Wood Composites(1997)

Raw Materials 3.10Mm3 Production Yield 90%→×0.9=2.79Mm3
Construction Use 40%→×0.4=1.12Mm3

Total 24.88Mm3 Carbon Stock ×0.25t-C/m3=6.22Mt-C

To begin with, the domestic production of sawn timber is 2.195 Mm3. There is the data of 1.219 Mm3 about the imported sawn timber, in which there may be the materials which are re-processed in domestic sawmills after being imported as semi-products and some of them may be double-counted in domestic production. The 80 % of the demand for sawn timber is used for construction, 10% for wooden boxes, 3 % for furniture and fixtures, and 4 % for civil engineering. So that, the quantity of sawn timber for construction sector is estimated to be 2.731 Mm3.

Here, the problem is the yield rate of the timber remained after wood processing and fixed into buildings. There is a research result that the yield rate in wood processing of the purchased sawn timber is 83 % in precut mills. That is to say, such ratio of wood is fixed into wooden houses actually. In the case of traditional carpenters adopting non-precut method, the yield rate is thought to be less than that of precut mills. It is said that the yield rate in processing into products of the purchased sawn timber is more than 90 % in prefabrication wooden house makers. The research result tells that the ratio of the discarded wood materials is about 1 % in construction site. Then, supposing that the ratio of sawn timber fixed into buildings is 80 %, 2.185 Mm3 is fixed.

Investigation of Wood Waste on Construction Site in 1998

Structure	Timber m3	Wooden Board m3	Total m3	Floor Area m2	Unit Input m3/m2	No. of Houses
Wooden Traditional	0.32	0.15	0.35	128.7	0.0027	87
Steel Pre-fab.	0.12	0.1	0.22	105.6	0.0021	10
Wooden Pre-fab.	0.2	0.1	0.3	95.7	0.0031	3

Next, the quantity of plywood production both domestic and imported is 9.55 m3. The half of plywood is for construction sector. But, plywood for concrete forms is not fixed into buildings, since almost all of them are discarded after several times use. The ratio of the plywood for forms increased according to the increase of RC-structure, and it is assumed to be about 30 % of the total quantity of plywood. The plywood sold as for forms is sometimes used for walls, then the actual circumstances have not been clarified. In addition, the problem of the yield rate exists as in the case of sawn timber. Here, the ratio of the plywood fixed into buildings is assumed to be 20 % of the total, and then, it becomes 1.91 Mm3.

There are not the data on production of wooden boards in volume, but by collecting the figures from the actual circumstances of raw materials as shown later, the value of 3.1 Mm3 is obtained in 1997. Assuming the yield rate in making products to be 90 %, the quantity of production equals to 2.79 Mm3. Because the figure is in terms of raw wood material, the specific gravity is supposed to be 0.5. Investigating each use, 40 % of wooden board is for construction, so the quantity becomes 1.12 Mm3. Though here is also a problem about the yield rate in processing wooden board into buildings, this figure itself is used.

Summing these, the total injected wood fixed into buildings comes up to 24.88 Mm3. If this is shown in terms of carbon, it becomes 6.22 million ton, which is very close value of the 652 million tons of carbon fixed into newly built constructions in 1996 (this is trial-calculated in the last section), though the year data is different.

4) Life span of building

As is written before, the annual carbon change in buildings can be calculated using the construction statistical data in every year. However, the data on life span of buildings is needed in order to simulate the carbon stock in future and to acquire the political options.

Moreover, a great deal of research data show that energy consumption to build a wooden construction is smaller than RC-structure and others, since the original unit of energy consumption to produce construction materials is smaller in wooden ones. Yet, without the data on life span of buildings, it is impossible to estimate the total energy consumption in life cycle of a building. This means that the total energy consumption of wooden building and that of RC-structure becomes the same even if the only half energy of RC-structure is consumed to build wooden house but the life of wooden building are half of RC-structure.

Though the biggest reason of replacing buildings is thought to be matters in the buildings themselves such as being decrepit, there are a lot of other social and system reasons, and then, it is difficult to evaluate the real life span. Judging from the much shorter period of re-building in Japan than western countries, it is possible that products which can be used for longer time by the adequate maintenance in spite of their looking decrepit is demolished.

As an example of research results, a data is shown on houses re-built by the granting financing of Housing Loan Corporation in 1987.

Investigation of Life Span of Demolished Houses

Structure	Total	~4yr.	~9yr.	~14yr.	~19yr.	~24yr.	~29yr.	~34yr.	~39yr.	~44yr.	~49yr.	50~yr.	Average yr.
Total (No.)	2,027	72	7	122	342	374	237	185	97	113	38	440	35.6
Total (%)	100	3.6	0.3	6	16.9	18.5	11.7	9.1	4.8	5.6	1.9	21.7	
Wooden (No.)	1,870	59	6	101	292	334	225	177	96	110	37	433	36.8
Wooden (%)	100	3.2	0.3	5.4	15.6	17.9	12	9.5	5.1	5.9	2	23.2	
Non-Wooden (No.)	145	10	1	20	49	38	11	6	1	2	1	6	21.2
Non-Wooden (%)	100	6.9	0.7	13.8	33.8	26.2	7.6	4.1	0.7	1.4	0.7	4.1	
Unknown (No.)	12	3		1	1	2	1	2		1		1	21.5
Unknown (%)	100	25		8.3	8.3	16.7	8.3	16.7		8.3		8.3	

The average life span is 36.8 years for wooden houses and 21.2 years for non-wooden ones though there are not many non-wooden samples such as 145, 7 % of the total samples. This enlarged average owes greatly to the fact that the ratio of wooden houses re-built in more than 50 years, that is to say, the houses built before 1937 is highest. But, even if investigating the mode in houses whose life span is less than 50 years, the life span is less than 24 years for wooden houses and less than 19 years for non-wooden ones. From this, it can not be said that the life span of wooden houses is shorter than those of other types of structure.

Several data on the life span of non-wooden and non-residential buildings such as offices also exist, and there are some results that the life span is equivalent to that of wooden houses in the case of RC-structure offices and is shorter than that in the case of S-structure offices.

5) Recycle of wood

In the trial calculation of the wood injected into buildings mentioned above, almost all of the matters which are calculated on are the production from the new demand of wood in the year, though materials such as demolition wood are used for particle boards a little.

Again, in the test calculation of wood stock in buildings, it is presumed that the demolition wood causes the emission of the carbon dioxide.

However, by the reuse-type material recycle that such wood is recycled as columns or beams of newly built constructions again, or the cascade-type material recycle that wood is used as wooden boards and others as discussed later, the life span of long-lived wood products will be elongated. This leads also to the saving of wood resources, that is to say, to the fact that the area of sustainable forestry for timber production could be smaller, and then, this will make the function of the carbon sequestration in the forests higher. Moreover, by some kinds of recycling, processing energy suchlike for drying becomes smaller compared to products from green timber.

The energy recycle of the demolition wood contributes to the reduction of the emission of the carbon dioxide from the fossil fuel greatly, although this is not discussed in detail in this report.

Though there are few statistics about wooden wastes, the summarized results on the situation of the discharge and recycle in 1991 are shown.

Generation and Recycle of Wood Wastes(1991)

Total generation of Wood Wastes 37.46Mm3	Recycled(Rough Estimation) 19.23Mm3 Burnt and Buried(R.E.) 18.23Mm3
Wood Industry 15.66Mm3 Saw Mill 12.81Mm3 Plywood 2.70Mm3 Laminated Timber 0.15万m3	Recycled 14.83Mm3 Burnt and Buried 0.83Mm3
Except Wood Industry 21.80Mm3 Construction 18.60Mm3 Others 3.20Mm3	Recycled 4.40Mm3 Burnt and Buried 17.40Mm3

The discharge of wood materials is estimated to be 37.46 Mm3, 51 % of that is used for some recycles, 49 % for incineration or land fill that is a source of the carbon dioxide emission uselessly.

The 95 % of discarded wood from wood industries is used for the chip of pulp and paper or for thermal resource, power generation of wood drying and others effectively.

However, the only about 20 % of the discarded wood from non-wood industries which amounts to 58 % of the total is used again, and just 20 % of which is material-recycled to resources such as paper pulp and boards.

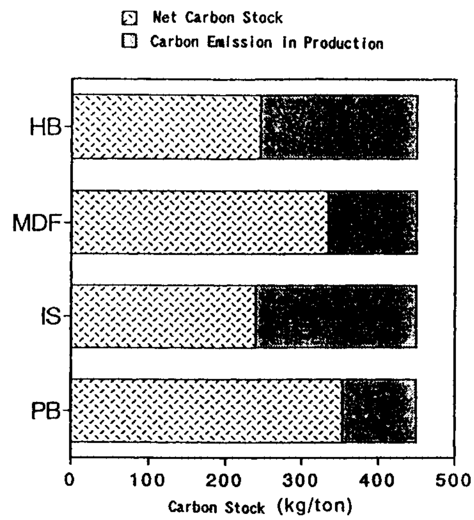
The quantity of the total incineration or land fill, 18.23 Mm3 is about 4.56 million ton in terms of carbon, this value is equivalent to about 1.5 % of the carbon emission from fossil fuel of our country in 1990. With the approaches on wood utilization except the flow approach, the carbon emission from wood utilization is not counted, but the some policies are clearly needed to utilize wood waste effectively.

6) Recycle of wood waste by wooden boards

It is possible that wooden boards such as particle board and fiber board take an important role in the wood waste recycle, just like pulp and paper discussed later.

First of all, the carbon balance in each kind of board is shown in a figure.

The quantity of the carbon fixed into the category of wooden boards per weight is often 0.45 compared to 0.5 for wood raw materials, so is 450 kg per 1 ton of products. Among it, the quantity subtracted the carbon emission in production is shown as the net carbon stock. The net carbon stock of hard board and insulation board belonging to the category of fiber board is small. And that of the medium density fiber board (MDF) is a little smaller than that of particle board. This is caused by the fact that the smaller elements for fiber board than particle board require more energy to produce the elements in using the equal quantity of chip. Since hard board and insulation board are often made with the wet process which the forming is conducted by dispersing fibers among water, more energy is needed for drying.



Carbon Stock of Wood Composites per 1t (450kg) and Carbon Emission in Production

HB: Hard Board, MDF: Medium Density Fiberboard, IS: Insulation Board, PB: Particle Board

When the net carbon stock is none, there is not an effect on the reduction in the carbon dioxide in our atmosphere, because the carbon emission in the production process equals to the carbon stock in products. The balance of the carbon is plus in any kind of wooden boards. However, weighing the merits compared to the reduction in the carbon emission derived from the fossil fuel by the energy recycle, since the energy efficiency per carbon of wood materials is about the half of the fossil fuel, unless the net carbon fixture is more than that, the temporary merit becomes small. From this sense, particle board and MDF are more effective. But, of course, the energy recycle is possible when the wooden boards are discarded after usage, too.

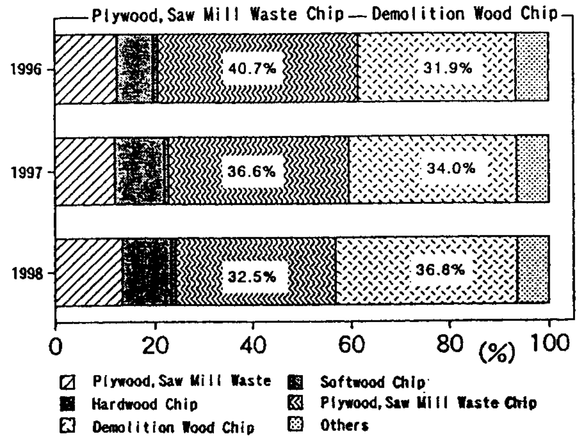
In addition, thinking the uses and the actual circumstances, the carbon is fixed till finishing life span of products and buildings on the case of the wooden boards used for materials for furniture and fixture or materials under floors. At this point, the efficiency on the carbon sequestration is higher than the recycle into the paper pulp whose life span as products is short.

The actual circumstances of raw materials for wooden boards are shown in a figure and a table.

Raw Materials of Wooden Board (Unit: 1000m3)

Year	Log	Plywood,Saw Mill Waste	Softwood Chip	Hardwood Chip	Plywood,Saw Mill Waste Chip	Demolition Wood Chip	Others	Total
1996	3.2	356	161	156	1520	783	179	3157
1997	3.4	327	206	125	1417	855	167	3101
1998	2.4	310	181	117	1135	801	142	2687

The total quantity of the raw materials for wooden boards in 1997 is 3.1 Mm3. Among that, the ratio of raw materials of logs and raw chip are 11 %, and the 90 % of the resources is obtained from the recycled resources such as wood waste from wood industries or demolition wood.



Raw Materials of Particleboard Production

However, it is necessary how to use the used wood such as demolition wood, most of which is incinerated or land filled uselessly. Then, the investigation on the real circumstances of using the used wood in particle board mills is carried out.

Eleven of 16 mills of 15 companies in our country are picked up through questionnaires and researching on the spot. This covers 75 % of total productions.

The ratio of using used materials in 1992 is 20 % of average, the ratios vary very large or small in some mills, even zero in some cases. Most of the mills which answered the questions predicted that the ratio of using the used wood would increase and the ratio after 5 years was 37 % of average.

According to the investigation on the actual results of the ratio of the utilization of the used wood in 1997, 5 years after the last research, the average is 40 %, this is about twice as much as that of the last research. Similarly, the ratio is predicted to reach 65 % after 5 years, furthermore, to come up to 74 % in future.

The examples which are different from the resources are shown in photographs.

The upper photo shows the demolition wood, the used wood quality is comparatively better and it is mainly derived from columns and beams. The under photo shows each used wood such as for pallets of forklift. However, all of the demolition wood is not so good like this, and it is thought that even worse wood with various shape and a lot of mixtures must be used in order to increase in the utilization of the used wood. This requires to overcome various technical problems.

The ratio of the used wood for particle board in 1992 and 1997 are shown in figures.

The ratio of demolition wood increased more than that in 1992, and this means that the importance is raised. Looking at the other used wood, the order is plywood for forms, pallets, and packaging materials.

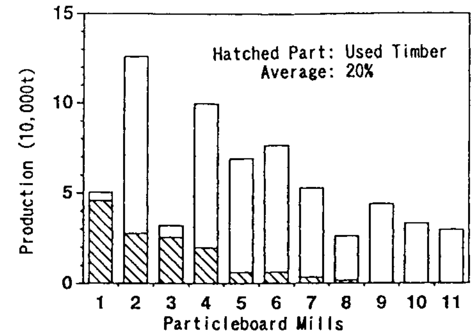
The suppliers of the used wood in 1992 and 1997 are shown in figures.

In 1992, a large rate of the used wood was supplied from demolisher directly, and chip was made from the used wood in their own mills. While, in 1997, the mills frequently buy the chip made by recycler. This indicates that recycler has become an industry and the change in distribution routes has been recognized.

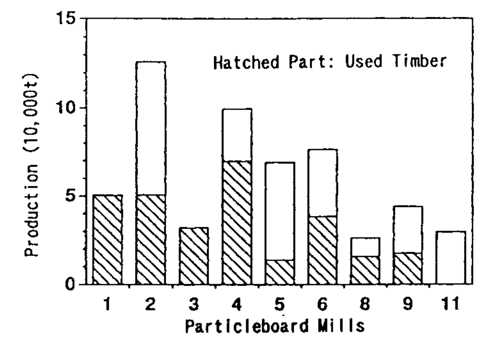
Shapes of chip from demolition wood are shown in a photograph. A is the chip made by cutting process, and it has enough performances to be used for paper makers who are particular about resource properties, and bears comparison with the virgin chip. B, C, and D are the chip produced by cracking process. Properties of chip influence on the performances of products largely, and hence, they are so important and the essential problem of recycle.

The research results of the problems in using the used wood in 1992 and 1997 are shown.

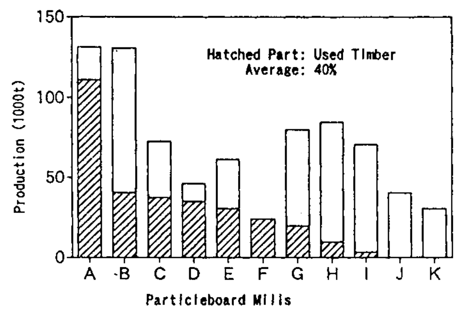
In both years, cleaning and removing foreign materials in wood chip is regarded as the biggest problem. This is related to the methods such as demolishing. The anxiety about the supply decreased in this 5 years, and this means the establishment of the distribution routes.



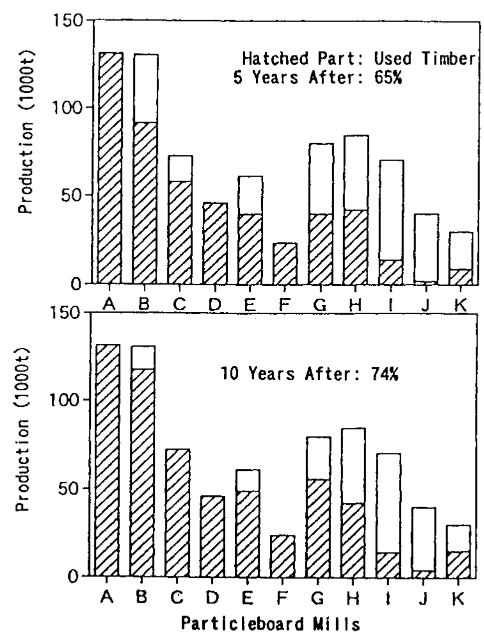
Production and Used Timber Ratio of Particleboard Mills (1992)



Prediction on Used Timber Usage of Particleboard Mills (1992)
5 Years After: 37%, 10 Years After: 45%



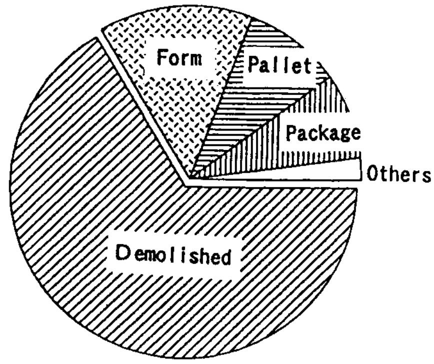
Production and Used Timber Ratio of Particleboard Mills (1997)



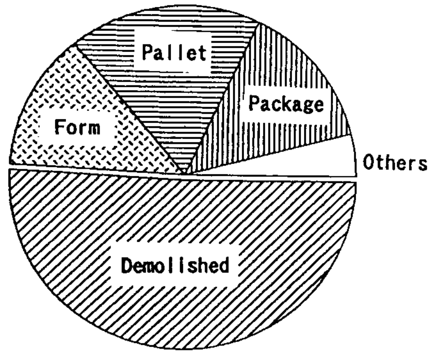
Prediction on Used Timber Usage of Particleboard Mills (1998)

Upper: Demolished Timber
(Columns and Beams from Wooden Houses)
Lower: Other Kind of Used Timber (Pallets etc.)

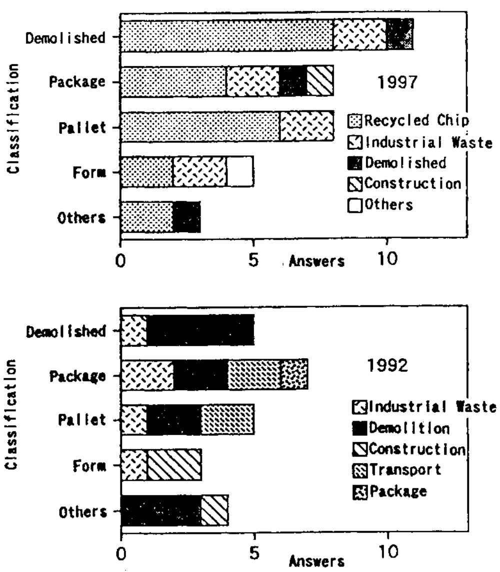
Collected Wood Wastes for Recycle



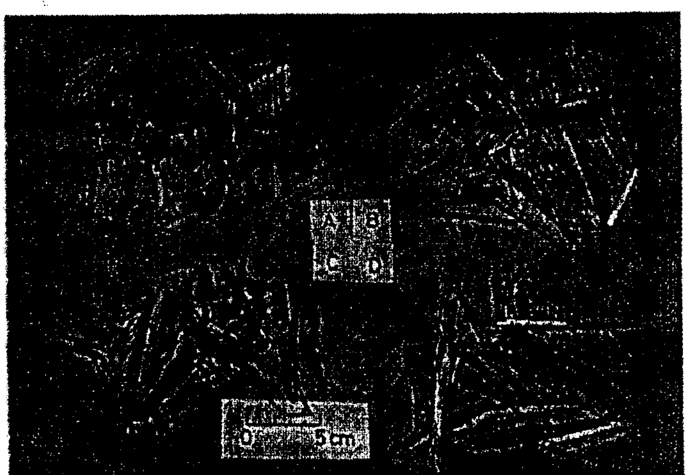
Used Timbers for Particleboard in 1997



Used Timbers for Particleboard in 1992



Suppliers of Used Timber



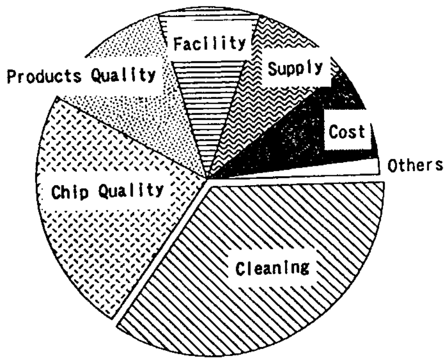
A : Cutting Process, P-Chip
B,C,D : Cracking Process, S-Chip

Shapes of Demolition Wood Chip

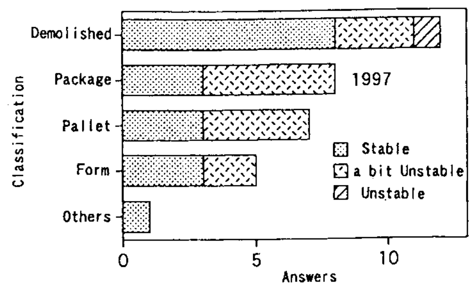
Since materials such as board are produced by continuous process, the recycle can not go without the stable supply of resources. Then, the research results about the difficulty in obtaining the used wood resource in 1992 and 1997 are shown.

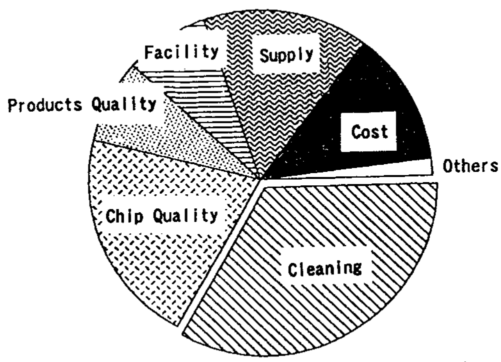
Just one company answered that the supply of demolition wood was stable in 1992, while, at present, such supply has become much stable.

The carbon fixed into materials such as wooden boards is estimated to be about 700 thousand ton these days. Among that, the carbon from demolition wood is thought to be about 190 thousand ton. It is expected that the increase in the ratio of using demolition wood, which is almost incinerated or land filled, will contribute the carbon stock as boards hereafter.

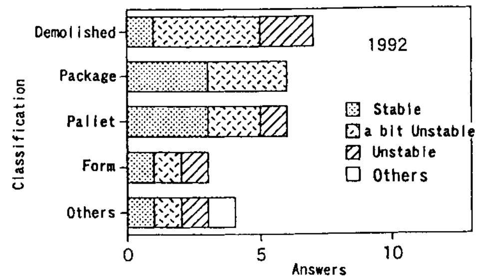


Problems on Recycling of Used Timber (1997)





Problems on Recycling of Used Timber (1992)



Difficulty to Get Used Timber

7) Carbon stock into paper pulp

The domestic production of paper and pasteboard in 1997 is 31.01 million ton. The quantity of export is 0.88 million ton, so the domestic consumption is 30.13 million ton. This is about 15.07 million ton in terms of carbon, and is the maximum value as the carbon flow from wood in our county.

It is clear that the quantity of wood for chip is 44.23 Mm3 and by adding 6.09 Mm3 from wood waste to the quantity, the value reaches 50.32 Mm3, and this is largest also among wood demand even if the demand for wooden boards is subtracted.

At the discussion in IPCC on the carbon stock into paper, the change in stock is sometimes neglected as almost none even if the flow is large. But the possibility of stock is investigated from the aspect of the absolute value of the carbon flow as mentioned above.

The ratio of collecting used paper in our country is 54 %, one of the highest in the world, and nearly 100 % of newspaper is collected. The quantity of used paper consumed in 1997 is 16.5 million ton. Calculating backward from this value, about 15 million ton is not collected. It is thought that 2/3 of them is the material such as toilet paper which can not be collected nor recycled. The rest is 5 million ton, that is, 2.5 million ton in terms of carbon, and it may be incinerated or increase in stock.

(5) Problems to be solved

When the change in the carbon stock by the long-lived wood products utilization is calculated, the biggest problem is the accuracy of the estimation. In the discussion at the COP, the absorption of the carbon dioxide by the forests and the carbon stock by the long-lived wood products utilization are scheduled to be assessed by linking them to the reduction of the carbon emission caused by the fossil fuel. Hence, the accuracy of the estimation equivalent to the fossil fuel will be needed.

The statistic data on the wood demand and supply and that on the wood injected to buildings are expressed in terms of the volume (m3) in almost all cases. This is because of the nonsense of using wood weight since the weight depends on the water state, for example, the weight of green wood is more than twice as heavy as that of dried wood. Therefore, assuming the oven dried weight which does not contain any water is needed in order to estimate the carbon in wood from the volume data.

Accordingly, the data on the specific gravity (density) that is weight per volume are needed. The specific gravity of coniferous wood used in our country varies around 0.4 - 0.6 even in the coniferous wood for building. Since the specific gravity has a variation even in the same wood species, for example, 0.27 - 0.41 for Sugi wood (Japanese cedar, Cryptomeria japonica D. Don.), then estimation is difficult.

But there are the statistic data on the average specific gravity of each wood species, and then, the accuracy of the estimation will increase by collecting demand of each wood species.

There are the statistic data on each uses and on each structure of newly built constructions in terms of m2. Then, the accuracy of estimating the quantity of wood which is newly added to the stock can be attained with the more careful analysis if a great deal of data on the timber input units into the buildings with various uses and structures are collected.

On the other hand, in the statistics about the demolished buildings which are lost from the stock, the only 2 categories of value of wooden buildings and non-wooden ones although there are values on each uses. As mentioned above, since it is possible for the timber input unit to depend on the era and the passed years at the moment of demolishing have some variations, the accuracy of the estimation of the demolished constructions can not help decreasing than newly built constructions.

The quantity of the wood injected from wood industries into construction sector can be assumed from the shipments data. The problem, however, is the yield rate which means the quantity of wood fixed into buildings really. On the actual circumstances of the plywood for forms, data collection is needed. In any case, cross-checking using both data will improve the accuracy of the estimation.

Moreover, the carbon stock by the furniture and others is not thought to be too small to be neglected, though this is not discussed in detail in this report.

Because the flow in the paper pulp is great, it will be necessary to examine the real change in the stock.

In the effects of wood utilization on the global warming, there are the energy saving effect and the energy replacing effect.

The energy saving effect by substituting other materials into wood must be reflected in the policy through calculating more realistic results.

Relating to this, for instance, analyses of the life span of wooden buildings and non-wooden ones are needed so as to evaluate the life cycle CO2 of products. And the running energy of buildings is about twice as much as building energy in our country. Therefore, it is important to compare wooden buildings to non-wooden ones in the running energy.

Although the problem of the recycle and wood waste is essential in the resource saving, the energy saving, and the carbon stock, the actual circumstances have not been clarified as statistics. Moreover, this must be compared to the energy recycling through the accurate life cycle assessment about products.

The effect of energy replacing by wood has been said to be most sustainable from the viewpoint of the reduction of the carbon dioxide. We consider that it is important to clarify the potential in using wood waste.

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