B-14.2.1 Technology assessment for the development of an Eco-house

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Abstract Carbon dioxide emission from residential sector of Japan has been increasing due to the changes in living quality and life style. Growing rate of energy consumption from residential sector during 1980 and 1990 was more than 24%. Carbon dioxide emission rate from residential sector is approximately 23% comparing with the whole carbon dioxide emission in Japan, and 12% is household emission.

As countermeasures to cope with global warming it is important to establish the control and reduction system of carbon dioxide from residential sector.The major purposes of this study were to investigate the reduction system of carbon dioxide emission from residential sector.

The data obtained from model simulation study , measurement in model house and experimentation on living persons in artificial environmental simulator were analyzed. Forecast the future for the reduction amount of carbon dioxide emission from residential sector owing to the introduction of Eco-house was conducted based on model simulation. Technology assessment for the development of an Eco-house was also conducted.

Key Words Eco-house, Domestic energy consumption, Super insulated construction house, Low infiltration construction house.

1. Introduction

Average emission share from residential sector in 1995:shares by house heating,air conditioning, hot water supply, and other use like motive power and lighting are approximately 27%,2.3%,35% and 36% respectively.

Promotion of super insulated and low infiltrated construction house is efficient for the reduction of house heating energy and solar panel system is efficient for the reduction of energy for hot water supply. Solar battery system is also available for use as a countermeasure in residential sector to cope with global warming.

To promote the use of these low energy house it is necessary to establish the concept of an Eco-house. Insulated construction house and low infiltration construction house is being widely used in Hokkaido district to improve the house heating efficiency in winter time, but these houses are not much popular in another part of Japan.To promote the use of an Eco-house, it is necessary to clarify the regional characteristics of the thermal performance of an Eco-house and the occupant's behavior. In this study the present technical status of an Eco-house is discussed.

2. Research Objective

Carbon dioxide emission in Japan is estimated 46056 kt-C in 2000 and 55399 kt-C in 2010. Carbon dioxide emission from residential sector has been increasing. Growing rate of energy consumption from residential sector during 1980 and 1990 was more than 24%. Carbon dioxide emission rate from residential sector is approximately 23% comparing with the whole carbon dioxide emission in Japan, and 12% is household emission.

As countermeasures to cope with global warming it is important to establish the control and reduction system of carbon dioxide from residential sector. The major research objective of this study was to investigate the reduction system of carbon dioxide emission from residential sector and conduct the technology assessment for the development of an Eco-house.

3.Result and Discussion

3.1 Model evaluation of an Eco-house system

Reduction of carbon dioxide emission from residential sector due to the promotion of an Eco-house were conducted. A new conventional wooden construction house, which mainly differs in the amount of insulation and construction method was investigated using simulation model. Construction method was also discussed. Comparison of annual carbon dioxide emission from house construction process and emission from residence for various house insulation, infiltration and equipment level were conducted.

Table 1. Estimated carbon dioxide emission from a detached house of (A):133m^2 and (B):155m^2 in area constructed in seven cities. (C-kg/household/year)

Case I:Super insulated and low infiltration house (Eco-house).

Case II:New insulated and low infiltration level which is presently used for house construction.

【C】:Continuous heating for all rooms,

【I】:Intermittent heating and cooling for selected room.

Case	Case I 【C】 (1)	Case I 【I】 (2)	Case II 【C】 (3)	Case II 【I】 (4)	(1)/(3)	(2)/(4)	(2)/(1)	(4)/(3)
			【Sapporo】					
(A)	1340	1703	1854	2722	0.72	0.63	1.27	1.47
(B)	1517	2010	1988	3152	0.76	0.64	1.32	1.59
(B)/(A)	1.13	1.18	1.07	1.16				
			【Sendai】					
(A)	1184	1406	1666	2390	0.71	0.59	1.19	1.43
(B)	1310	1625	1794	2812	0.73	0.58	1.24	1.57
(B)/(A)	1.11	1.16	1.08	1.18				
			【Niigata】					
(A)	1315	1546	1765	2507	0.75	0.62	1.18	1.42
(B)	1425	1761	1865	2895	0.76	0.61	1.24	1.55
(B)/(A)	1.08	1.14	1.06	1.15				
			【Tokyo】					
(A)	1108	1234	1467	1950	0.76	0.63	1.11	1.33
(B)	1219	1423	1578	2281	0.77	0.62	1.17	1.45
(B)/(A)	1.10	1.15	1.08	1.17				
			【Yonago】					
(A)	1179	1369	1618	2269	0.73	0.60	1.16	1.40
(B)	1291	1579	1729	2668	0.75	0.59	1.22	1.54
(B)/(A)	1.09	1.15	1.07	1.18				
			【Hiroshima】					
(A)	1077	1212	1452	1978	0.74	0.61	1.13	1.36
(B)	1179	1392	1579	2342	0.75	0.59	1.18	1.48
(B)/(A)	1.09	1.15	1.09	1.18				
			【Kagoshima】					
(A)	994	1084	1294	1714	0.77	0.63	1.09	1.32
(B)	1093	1243	1426	2019	0.77	0.62	1.14	1.42
(B)/(A)	1.10	1.15	1.10	1.18				

(C-kg/household/year)

Estimated annual carbon dioxide emission rate from house construction process was 407(Ckg/house). In this estimation life time of house is assumed 30 years. Annual carbon dioxide emission rate from residence in seven cities were estimated under the six types of specification of insulation and infiltration levels and equipments. For the base case emission of carbon dioxide from new insulation and infiltration level house which is presently used for new construction was estimated. For example in Sapporo and Tokyo showed 3152 and 2281(Ckg/household) respectively. For the case of super insulated and low infiltration construction house this value is decreased to 2010 and 1423(Ckg/household) respectively. This reduction rate of carbon dioxide is much higher than the emission of house construction processes, and it was found that the promotion of an super insulated and infiltration construction house is efficient to reduce carbon dioxide emission from residential sector.

To clarify the difference in area of detached house for carbon dioxide emission an comparison study was conducted. Comparison between 155 square meter and 133 square meter in area is shown in Table.1. The annual carbon dioxide emission increases approximately 10% in case of intermittent heating system and 14-18% in continuous heating system respectively.

Forecast the future for the reduction amount of carbon dioxide emission from residential sector owing to the introduction of Eco-house was also conducted based on model simulation. Calculated reduction rate of carbon dioxide emission from residential sector due to the promotion of an Eco-house is shown in Table.2. Newly constructed detached house is approximately 2.9% in 1996 for the total existing detached house in Japan. Nation wide total reduction amount of carbon dioxide emission from residential sector due to the introduction of Eco-house were estimated assuming three different Eco-house introduction scenario. A 100% accomplishment period for the introduction of a Eco-house is assumed ten years, five years and one year. Estimated results showed 6-9% reduction for the total forecasted emission of carbon dioxide from residential sector in 2010.

Table 2. Calculated reduction rate of carbon dioxide emission from a residential sector due to the promotion of an Eco-house.

【scenario I】 :A 100% accomplishment period for the introduction of Eco-house is assumed one year.
【scenario II】 :A 100% accomplishment period for the introduction of Eco-house is assumed five years.
【scenario III】 :A 100% accomplishment period for the introduction of Eco-house is assumed ten years.

Year		1998	2000	2010
Estimated CO_2 emission in Japan (kt-C)*		37,351	46,056	55,399
【scenario I】	CO_2 reduction amount (kt-C)	▲ 285	▲ 971	▲ 4910
	CO_2 reduction rate (%)	0.8%	2.1%	8.9%
【scenario II】	CO_2 reduction amount (kt-C)	▲ 57	▲ 384	▲ 4171
	CO_2 reduction rate (%)	0.2%	0.8%	7.5%
【scenario III】	CO_2 reduction amount (kt-C)	▲ 29	▲ 192	▲3168
	CO_2 reduction rate (%)	0.1%	0.4%	5.7%

*Enviromment Agency (March 1997), ＜residential sector＞

3.2 Promotion of an Eco-house system

Improvement in construction method of a new conventional wooden construction house was investigated. Insulated construction house and low infiltration construction house is being widely used in Hokkaido district to improve the house heating efficiency in winter time, but these houses are not much popular in another part of Japan.To promote the use of low energy house it is necessary to improve the information exchange between house user, house maker, house equipment maker, constructor, architect and researcher.

Construction method of a"new conventional wooden construction house", which is mainly different from the amount of insulator and construction method, was investigated based on model simulation and field survey.

Results showed kerosene consumption of the house in Tokyo area is reduced one third and living condition is also improved comparing with conventional wooden house and new conventional wooden house, which is commonly used in Hokkaido district. Comparison of annual carbon dioxide emission from house construction process and emission from residence for various house insulation, infiltration and equipment level were conducted.

Calculated results showed that the carbon dioxide emission from the house is reduced 20～40% compared with conventional wood house and the new conventional wood house. It was found that the promotion of an super insulated and infiltration construction house is very efficient to reduce carbon dioxide emission from residential sector.

To clarify the living quality of Eco-house, measurement was conducted in northern Kanto and Tohoku districts. The observational results showed the importance of ventilation and solar heat shading to improve the living quality in summer season.

3.3 Thermal performance of an Eco-house

Long term investigation of indoor thermal environment and energy performance in an actual detached house with passive solar system constructed in Sendai was conducted. Observational results showed comfortable living condition in winter but hot room temperature in summer season. Observational result during three years are shown in Fig.1.

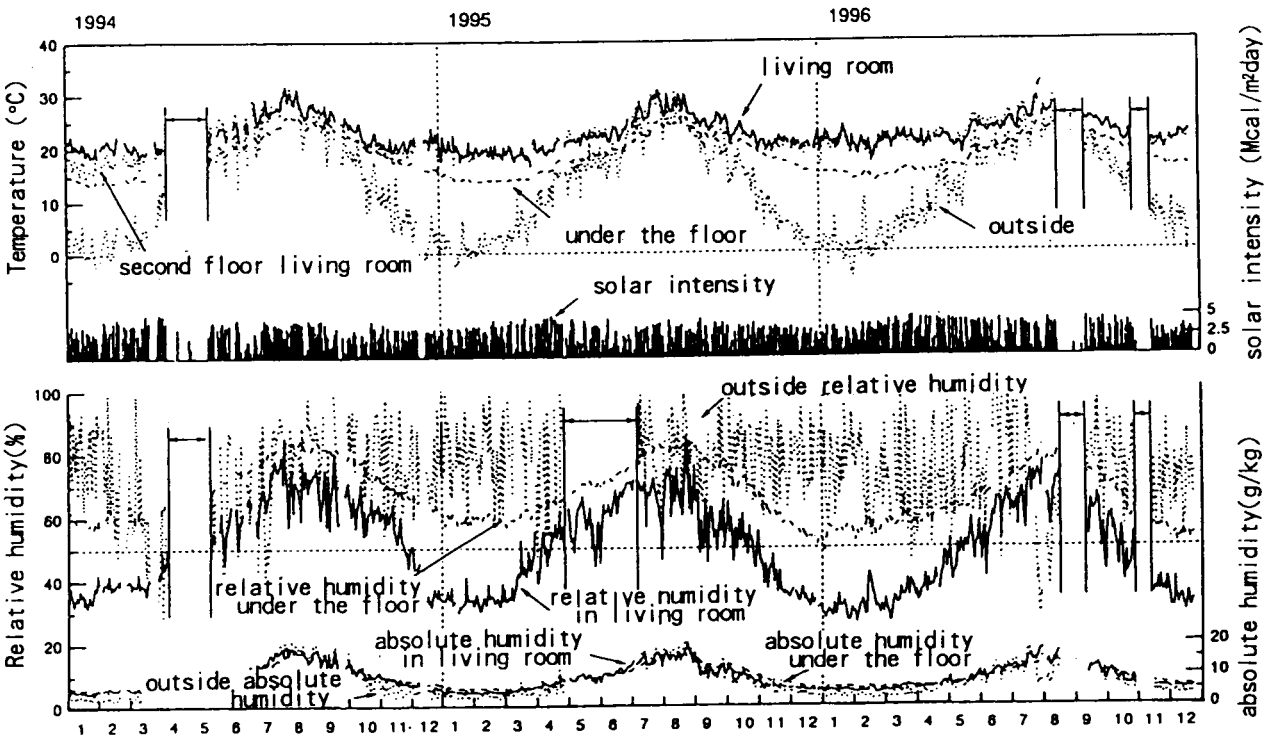

Figure 1. Daily average temperature and humidity observed at the various rooms in the model house in Sendai during three years.

3.4 Evaluation of living quality in an Eco-house

Artificial light wind flow system in summer season was also investigated to improve the pleasantness of dweller and reduction of energy consumption of an Eco-house. Artificial ventilation system was investigated to improve the thermal condition in summer season.

Observational results during three years were analyzed. Relationships between wind velocity, room temperature and pleasantness observed in this investigation are shown in Fig.2. In this figure -2

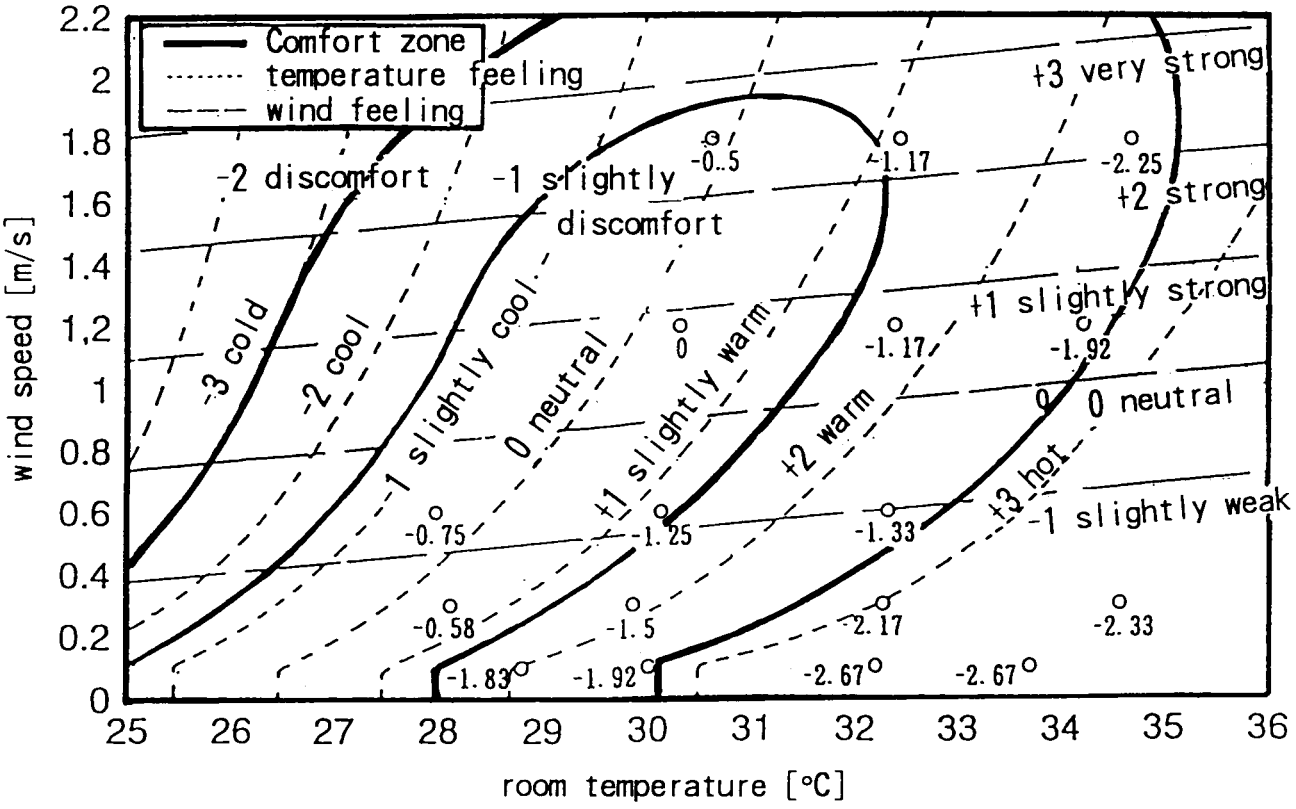

Figure 2. Relationship between wind speed, room temperature and comfort zone.

means discomfort and -1 means slightly discomfort zone respectively. It is important result that even if room temperature goes up more than 27 degree C comfort zone is observed if wind speed is 0.4 to 0.8 m/s .Energy consumption of this artificial wind flow system is one tenth comparing with electric cooler in summer season.

4. Summary

Technology assessment for the development and promotion of an Eco-house system were conducted. The major purposes of this study were to investigate the reduction system of carbon dioxide emission from residential sector. The data obtained from model simulation study , measurement in model house and experimentation on living persons in artificial environmental simulator were analyzed. Forecast the future for the reduction amount of carbon dioxide emission from residential sector owing to the introduction of an Eco-house was conducted based on model simulation.Artificial light wind flow system in summer season was also investigated to improve the pleasantness of dweller and reduction of energy consumption of an Eco-house, technology assessment for the development of an Eco-house were also conducted. To promote the use of the low energy houses it is necessary to improve the information exchange between house owners,house makers, house equipment makers, constructors, architects and researchers.Meteorological conditions, contraction method and construction costs combined with the social system must be also considered.