B-16.3.2 Promotion of Lifestyle in Houses with Low CO_2 Emission Rate

Contact Person Kazuaki Bohgaki
Takao Sawachi
Building Service Control Division, Environment, Design and Fire Dept.,
Building Research Institute, Ministry of Construction,
Tatehara 1 Tsukuba, Ibaraki 305 Japan
Phone +81-298-64-2151(ext.426 or 279), Fax +81-298-64-6775

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Abstract

When a performance of some residential building is to be evaluated reasonably, which is claimed to be well designed and to have good energy efficiency, it is desirable that observed energy consumption under dwelling should be compared with average energy consumption in the same condition of climate, building type and lifestyle (family characteristics). In this subtheme, based on a national scale survey in Japan, actual energy consumption data is analyzed, and estimation formulas of different use of energy are presented with discussion on determinant factors of residential energy consumption. In addition, during FY1992-1993, a textbook dealing with knowledge and concept which is necessary in order to help lifestyle with low CO_2 emission rate, has been developped. The textbook consists of many illustrations and short comments for each themes, and is designed to be understandable for people elder then junior high school students.

Key Words Lifestyle, Energy Consumption, Environmental Education

PART 1: SURVEY ON LIFESTYLE AND RESIDENTIAL ENERGY CONSUMPTION

1. Method of Survey

The survey consists of questionnaire, energy consumption inquiry to supply companies and indoor temperature measurement. For the survey, a project team whose members came from eight universities located in the eight cities was organized. Two types of questionnaires were developed for summer investigation in 1992 and winter one in 1993, both of which have the same subjects (Each subject were requested to answer two types of questionnaires for different seasons). The questionnaires had questions about residents' behavior, attitude and subjective evaluation related to the way of indoor climate control. They also include the questions related to factors which are presupposed to determine energy consumption for other energy uses, such as hot-water supply, etc. Since different natural features in eight cities seem to form varied life style, questions were carefully examined in the project team.

2. Subjects

The fields of this survey are eight cities of broad climatic conditions (Table 1). Total number of subjects are 2169 in summer and 1675 in winter. Subject group of each city consists of five types of houses. They are detached house located in suburb of the city, condominium (flat owned by each family) in urban (downtown) area, condominium in suburb, apartment (flat leased by local government or public corporation) in urban area and apartment in suburb. All subject houses except for No.22 and No.23 were built under clientship of public corporation or local government. All subject buildings were built in 1980s and 1990s after the Criteria for Owner's Judgement on the Energy Efficient Utilization in Residential Buildings was proclaimed in 1979.

3. Items of Survey

All items of the survey can be summarized into the following five groups, the last two groups of which are not dealt in this paper.

(1)monthly data of electricity, gas, kerosene and water consumption

Except for kerosene, the data was obained from energy suuply companies and local government supplying water only for subjects who gave us an acceptance letter of our inquiry. The number of subjects who accepted the inquiry is 1544. As for the data of kerosene, there is no way other than self data entry by the subject on the questinnaire. To avoid usage of inaccurate data entry, we added the question which asks subjects what percentage the written amount of kerosene seems to be of actual total consumption of kerosene, and data were omitted when the percentage was lower than 60%. In this paper, energy consumption is expressed in secondary energy basis, and conversion coefficients are 860 Kcal/Kwh, 8900 Kcal/lit. and calorific value of each type of gas.

(2)equipment usage pattern

The following items were inquired: (a) Type, installed rooms, seasonal period and time zone of use of heaters and air conditioners, (b) weekly number of times of bath and shower for four seasons, (c) ownership of larger size electrical appliances.

(3)life style

The following items were inquired: (a) family members' age, occupation and income rank (based on total income including tax), (b) daily time allocation to different activities, such as sleeping, leasure, care of children and commuting, (c) attitude for environmental protection and energy conservation.

(4)temperature in living room

It is natural that the room temperature should vary according to residents' response to climate. It is quite

Table 1 List of subjects

City Name Heating Degree Day (18-18) Cooling Degree Day (24-24)	Code	Type of House	Location	Number of Samples (for Questionnair Survey) Summer	Number of Samples (for Questionnair Survey) Winter	Average Floor Area Unit:sqm	Complebon
Sapporo HDD_{18-18}=3,886 CDD_{24-24}= 0	11	Detached House	suburban	41	26	118.9	1989
	12	Condominium	urban	34	30	84.0	1988
	13	Condominium	suburban	28	26	85.6	1981
	14	Apartment	urban	32	26	68.0	1981
	15	Apartment	suburban	28	25	61.3	1990
Sendai HDD_{18-18}=2,708 CDD_{24-24}= 10	21	Detached House	suburban	33	27	No Data	1986
	22	Condominium	urban	22	17	71.4	1990
	23	Condominium	suburban	16	13	84.5	1991
	24	Apartment	urban	104	61	68.1	1988
	25	Apartment	suburban	66	50	78.3	1987
Niigata HDD_{18-18}=2,411 CDD_{24-24}= 74	31	Detached House	suburban	64	58	109.6	1986
	32	Condominium	urban	50	44	72.1	1985
	-	Condominium	suburban	0	0	-	-
	34	Apartment	urban	58	46	60.6	1985
	35	Apartment	suburban	60	50	61.9	1986
Tokyo HDD_{18-18}=1,838 CDD_{24-24}= 130	41	Detached House	suburban	57	40	111.5	1987
	42	Condominium	urban	34	30	61.7	1985
	43	Condominium	suburban	39	32	75.3	1988
	44	Apartment	urban	33	26	65.3	1989
	45	Apartment	suburban	39	30	65.8	1989
Nagoya HDD_{18-18}=1,987 CDD_{24-24}= 142	51	Detached House	suburban	47	40	117.2	1989
	52	Condominium	urban	31	26	74.2	1988
	53	Condominium	suburban	24	21	79.5	1983
	54	Apartment	urban	28	24	69.7	1989
	55	Apartment	suburban	24	18	65.8	1989
Kyoto HDD_{18-18}=1,977 CDD_{24-24}= 191	61	Detached House	suburban	59	52	107.3	1988
	62	Condominium	urban	26	22	63.8	1980
	63	Condominium	suburban	26	25	92.9	1991
	64	Apartment	urban	35	34	66.5	1989
	65	Apartment	suburban	29	28	63.6	1987
Fukuoka HDD_{18-18}=1,671 CDD_{24-24}= 197	71	Detached House	suburban	494	329	110.0	1985
	72	Condominium	urban	17	14	68.0	1983
	73	Condominium	suburban	209	140	76.3	1988
	74	Apartment	urban	26	23	66.5	1991
	75	Apartment	suburban	31	24	61.4	1988
Naha HDD_{18-18}= 0 CDD_{24-24}= 425	81	Detached House	suburban	60	49	80.0	1985
	82	Condominium	urban	40	39	81.0	1990
	83	Condominium	suburban	16	14	79.0	1984
	84	Apartment	urban	54	44	66.0	1985
	85	Apartment	suburban	55	52	64.0	1987
Total Number of Samples				2169	1675		

Table 2 Estimation of Energy Consumption for Different Uses

Unit: Mcal/Year/Household (Secondary Energy Basis)

City Name	Code	Type and Location	Energy Consumption for Different Uses										Total	
			Heating		Air Conditioning		Hot-Water Supply		Cooking		Other Uses incl. Lighting			
Sapporo	11	detached/suburban	13,939	61.2%	0	0.0%	5,447	23.9%	899	3.9%	2,474	10.9%	22,760	
	12	condominium/urban	4,908	38.2%	0	0.0%	4,897	38.1%	805	6.3%	2,247	17.5%	12,858	
	13	condominium/suburban	5,542	44.6%	0	0.0%	3,848	30.9%	929	7.5%	2,118	17.0%	12,438	
	14	apartment/urban	9,209	60.0%	0	0.0%	3,327	21.7%	918	6.0%	1,902	12.4%	15,357	
	15	apartment/suburban	2,211	32.2%	0	0.0%	2,308	33.6%	829	12.1%	1,520	22.1%	6,869	*1
Sendai	21	detached/suburban	5,713	36.1%	13	0.1%	6,006	38.0%	1,041	6.6%	3,036	19.2%	15,810	
	22	condominium/urban	3,142	28.4%	4	0.0%	3,632	32.8%	870	7.9%	3,417	30.9%	11,066	
	23	condominium/suburban	1,789	23.6%	33	0.4%	3,138	41.3%	790	10.4%	1,845	24.3%	7,596	
	24	apartment/urban	2,206	22.2%	4	0.0%	4,800	48.3%	891	9.0%	2,036	20.5%	9,938	
	25	apartment/suburban	2,731	28.5%	25	0.3%	4,337	45.2%	847	8.8%	1,654	17.2%	9,595	
Niigata	31	detached/suburban	3,122	25.5%	83	0.7%	5,716	46.6%	868	7.1%	2,475	20.2%	12,265	
	32	condominium/urban	3,103	27.6%	202	1.8%	5,103	45.4%	924	8.2%	1,896	16.9%	11,230	
	33	condominium/suburban	-	-	-	-	-	-	-	-	-	-	-	
	34	apartment/urban	2,002	27.2%	51	0.7%	3,027	41.1%	884	12.0%	1,395	19.0%	7,360	
	35	apartment/suburban	2,086	26.9%	73	0.9%	3,096	39.9%	866	11.2%	1,644	21.2%	7,766	
Tokyo	41	detached/suburban	2,653	22.3%	237	2.0%	5,525	46.4%	928	7.8%	2,568	21.6%	11,912	
	42	condominium/urban	1,254	10.3%	472	3.9%	6,580	54.0%	899	7.4%	2,979	24.4%	12,185	
	43	condominium/suburban	1,148	13.3%	80	0.9%	4,279	49.4%	940	10.8%	2,216	25.6%	8,664	
	44	apartment/urban	626	7.4%	74	0.9%	4,707	55.8%	999	11.8%	2,026	24.0%	8,433	
	45	apartment/suburban	2,046	24.4%	264	3.2%	3,559	42.5%	801	9.6%	1,706	20.4%	8,377	
Nagoya	51	detached/suburban	3,504	28.7%	102	0.8%	5,085	41.6%	816	6.7%	2,716	22.2%	12,225	
	52	condominium/urban	1,198	13.8%	204	2.3%	3,865	44.4%	875	10.0%	2,567	29.5%	8,710	
	53	condominium/suburban	1,800	17.3%	23	0.2%	5,112	49.1%	956	9.2%	2,525	24.2%	10,417	
	54	apartment/urban	871	10.6%	70	0.9%	3,871	47.3%	938	11.5%	2,428	29.7%	8,179	
	55	apartment/suburban	1,754	22.0%	163	2.0%	3,425	42.9%	780	9.8%	1,861	23.3%	7,984	
Kyoto	61	detached/suburban	2,406	19.7%	156	1.3%	5,724	47.0%	1,030	8.5%	2,871	23.6%	12,188	
	62	condominium/urban	629	8.2%	163	2.1%	3,681	48.0%	887	11.6%	2,314	30.2%	7,675	
	63	condominium/suburban	1,154	12.8%	105	1.2%	4,359	48.4%	847	9.4%	2,541	28.2%	9,007	
	64	apartment/urban	1,419	17.9%	216	2.7%	3,230	40.7%	982	12.4%	2,087	26.3%	7,935	
	65	apartment/suburban	856	11.4%	130	1.7%	3,662	48.7%	788	10.5%	2,087	27.7%	7,524	
Fukuoka	71	detached/suburban	3,385	30.5%	122	1.1%	3,764	33.9%	931	8.4%	2,891	26.1%	11,094	
	72	condominium/urban	809	10.5%	162	2.1%	3,259	42.2%	865	11.2%	2,636	34.1%	7,731	
	73	condominium/suburban	1,064	11.9%	192	2.2%	4,090	45.8%	901	10.1%	2,680	30.0%	8,928	
	74	apartment/urban	1,681	22.5%	113	1.5%	2,995	40.0%	797	10.6%	1,897	25.3%	7,484	
	75	apartment/suburban	2,439	30.0%	106	1.3%	2,839	34.9%	882	10.9%	1,861	22.9%	8,128	
Naha	81	detached/suburban	76	0.9%	493	5.6%	4,016	45.5%	1,235	14.0%	3,010	34.1%	8,830	
	82	condominium/urban	99	1.5%	512	7.6%	2,373	35.4%	961	14.3%	2,757	41.1%	6,702	
	83	condominium/suburban	110	1.4%	466	5.9%	3,573	45.0%	1,023	12.9%	2,763	34.8%	7,935	
	84	apartment/urban	29	0.5%	351	5.7%	2,565	41.6%	953	15.5%	2,263	36.7%	6,161	
	85	apartment/suburban	210	3.6%	283	4.9%	2,366	41.0%	921	16.0%	1,989	34.5%	5,769	

*1 Heating energy is supplied heat by a district heating system.

Table 3 Textbook Contents for Environmental Education of Residential Life

1. In Search of Landscape
 1.1 Landscape in Memory
 1.2 Lost Landscape
 1.3 Present Landscape
 1.4 Future Landscape
2. Nature and Man Relation in Life
 2.1 Healthy Life
 2.2 History of Our Contact with Nature
 2.3 From Goods-depending Life to Environment Friendry Life
3. Considering Familiar Environment
 3.1 Daily Life and Climate
 3.2 Residential Regions and Topography
 3.3 Origin of Villages and Towns
 3.4 Form of Residential Buildings
 3.5 Natural Features of Native Place
4. Life, Energy and Global Environment
 4.1 Energy Consumption in Residential Life
 4.2 Relation between Energy Consumtion and Lifestyle
 4.3 Time is Energy
 4.4 Global Warming and Residential Life
 4.5 Future of Global Environment and Familiar Life
5. Lighting and Scenery in Residential Life
 5.1 Sun Light
 5.2 Seeing
 5.3 Design of Brightness
 5.4 Scenery and Visual Environment
6. Warm Residential Life in Winter
 6.1 Coldness and Body Temperature
 6.2 Feeling Warmth
 6.3 Fire and Energy
 6.4 Design and Behavior to Cope with Warmth
 6.5 Kotatsu, Stove and Central Heating
 6.6 Prevention of Condensation Problem
7. Cool Residential Life in Summer
 7.1 What is Hotness?
 7.2 Making Cool Place
 7.3 Ventilation Cooling
 7.4 Cool and Confortable Residential Buildings
 7.5 Design and Behavior to Cope with Warmth
 7.6 Air-Conditioning and Health
8. Noisy Sound and Music
 8.1 Pleasant Sound
 8.2 Noisy Sound
 8.3 Measuring Sound
 8.4 Daily Life without Making Noise
 8.5 Shutting out of Noise
 8.6 Vibration in Daily Life
 8.7 Enjoying Music
9. City and Green Environment
 9.1 Role of Green
 9.2 Green and Micro-Climate
 9.3 Green, Town and Residential Buildings
 9.4 Green in Landscape
 9.5 Environmental Pollution and Green
10. Forever Clean Water and Air
 10.1 Water Supporting Life
 10.2 Air Supporting Life
 10.3 Water and Air in Native Place
 10.4 Polluted Water
 10.5 Polluted Air
 10.6 Prevention of Water and Air Pollution
11. Management of Garbage
 11.1 Throwaway and Recycle
 11.2 Disposal of Garbage
 11.3 Behavior Reducing Garbage
 11.4 Recycle of Resources and Energy
12. Healthy and Comfortable Life
 12.1 What is Truly Comfortable Life?
 12.2 Environment Friendly Life

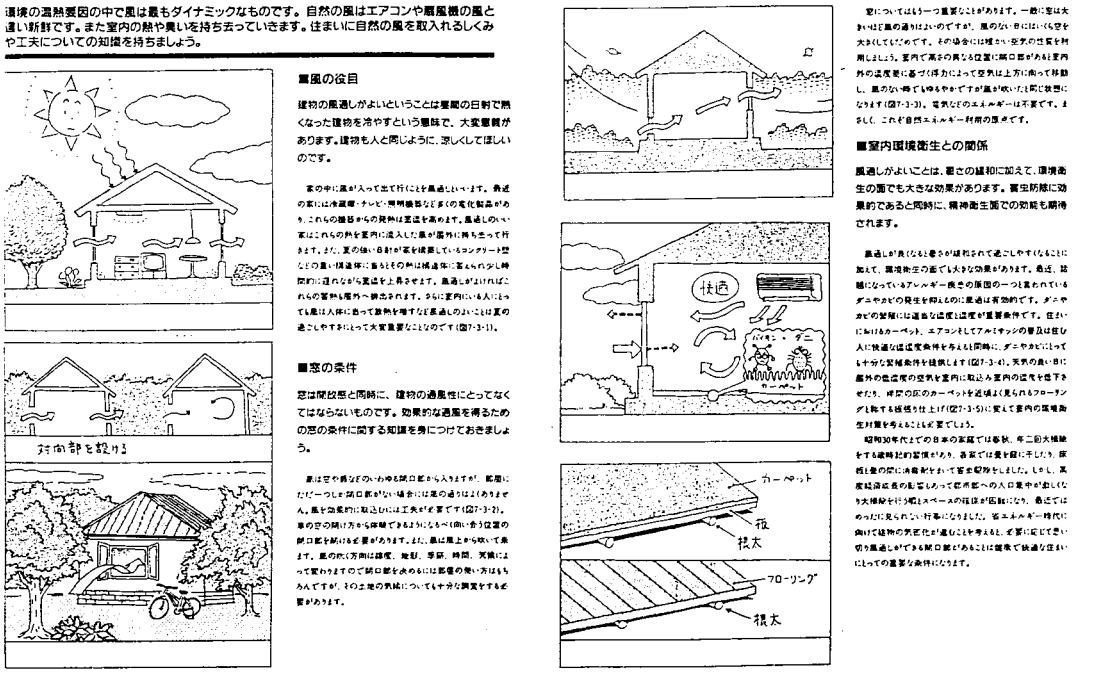

Figure 1 An Example of Contents of the textbook

common recognition in Japan that room temperature in winter in cold climate region such as Hokkaido is clearly higher than that in warmer climate regions. For this survey, an inexpensive automatic temperature recorder with RAM was newly designed and produced. For each city, living room temperature was measured in at least twenty-five houses. Total number of subjects whose temperature were measured was 375 in summer and 368 in winter.

(5)residents' behavioral response to their thermal environment and related attitude

It can be said that residents have more alternatives for controlling their thermal situation, where the climate is milder. The alternatives includes changing clothes or activities of different metabolism, moving to or staying in less uncomfortable places, tolerating intermittent thermal stress and so on. These factors seems to be key points to make clear the essential meaning of "comfort" especially in houses where occupants have higher controllability for the relationship between man and environment.

4. Estimation of Energy Consumption for Different Uses

Table 2 shows the estimation of energy consumption for heating, air conditioning, hot-water supply, cooking and electricity consumption for other uses including lighting. In the following analysis, determinant factors related to lifestyle(family size and life stage, income, type of residential building, climatic condition, behavior, etc.) were extracted, and predictive equation for different energy uses were produced.

PART 2: ENVIRONMENTAL EDUCATION TEXTBOOK FOR RESIDENTIAL LIFE

Contents of Textbook

Table 3 shows the contents of the textbook, which is A4 size, 140 Pages. It can be used in the school of which grade is higher than junior high school and in a course for people searching for dwellings,for example. It was intended that the contents were easy to read and understandable by using as many illustrations as possible. Figure 1 shows an example of the contents.

SUMMARY

Energy consumption for heating, air conditioning, hot-water supply, cooking and other electricity consumption including lighting can be estimated with monthly consumption data of each type of energy. In the estimation method, questionnaire data was useful and indispensable. The result is shown in Table 2. In the next step, determinant factors of each energy use were analyzed and regression equations were obtained.

In the later half of this subtheme, an educational tool for promoting lifestyle with low CO_2 emission rate was developped. In the textbook, knowledge and concept related to environment friendry residential life is described with many illustration and short comments for each topic.