

### **B-16.3.1 Relationship Between Temporal and Spatial Domestic Energy Consumption Patterns and the Urban Environment.**

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**Total Budget for FY1991-FY1993** 25,085,000 Yen (FY1993; 8,794,000 Yen)

**Abstract** To clarify the regional characteristics of the thermal performance of the houses and the occupant's behavior in winter time a survey using questionnaires was conducted focusing on Tohoku district and Sendai area. Comparison study with the result which observed ten years before showed living quality of Tohoku district is improving toward the level of living quality in Sapporo.

Statistical analysis to clarify the energy consumption trend from residential sector in Sendai and future emission estimation was conducted. Energy consumption trend from residential sector in Sendai was analyzed. In Sendai city gas consumption has been increasing. Future trend of carbon dioxide from household in Sendai is also estimated. The carbon monoxide emission from household in Sendai in 1990 is estimated 801 (1000tons/Year), in 2000 is 1,020, in 2010 is 1,049. After 2000 increasing speed will be decreased. Annual increase of total emission between 1990 to 2000 is 3.59% and between 2000 to 2010 it is 1.29%.

A series of wind tunnel Study was also conducted to clarify the relationship between model house locating interval and natural ventilation rate of house. Pressure differences were measured at four pairs located at wall and roof. Air change rate per hour decreases as model interval decrease due to the decrease of pressure difference especially at wall point measurement between windward wall and leeward wall. On the contrary when air comes from windward roof air change rate per hour showed small difference against the changes of model interval.

**Key Words** Domestic energy consumption, Residential environment,  
Urban environment

#### **1. Introduction**

The energy consumption from the residential sector is very much related to aspects of the urban climate change. The urban climate is also considered to be affected through the energy consumption from the residential and commercial sectors. Energy consumption from residential sector is increasing due to the change of life style. Under these conditions it will be important to clarify the relationship between the living style and environmental condition in control and reduction system of carbon dioxide emission from residential sector to cope with global warming.

#### **2. Research Purpose and Method**

The purpose of this study is to investigate the relationship between the life style and environment conditions. Statistical data of domestic energy consumption, temporal trend and spatial distribution are analyzed together with meteorological and economic conditions.

To clarify the regional characteristics of the thermal performance of the houses and the occupant's behavior in winter time a survey using questionnaires was conducted focusing on Tohoku district and Sendai area. Statistical analysis to clarify the energy consumption trend from residential sector in Sendai and future emission estimation was conducted. A series of wind tunnel Study was also conducted to clarify the relationship between model house locating interval and natural ventilation rate of house.

### 3. Results and Discussion

Regional characteristics of the thermal performance of the houses and the occupant's behavior in winter time was analyzed based on questionnaires of mainly focusing on Tohoku district and surrounding area. Statistical analysis showed that the regional characteristics of room heating style is divided into four groups.

Region (1): Sapporo and Aomori

Region (2): Hachinohe, Morioka, Akita and Yokote

Region (3): Miyako, Yamagata, Sakata, Sendai, Fukushima and Aizuwakamatsu

Region (4): Iwaki and Fuchu

In Region (1) room heating period is longer and kerosene consumption is higher compared with another group. Room temperature is high. Region (4) is opposite condition with Region (1). Region (2) and (3) are medium type and close to Region(1) and Region(4) respectively. Comparison study with the result which observed ten years before showed living quality of Tohoku district is improving toward the level of winter time living quality in Sapporo.

Energy consumption trend from residential sector in Sendai was analyzed. Annual trend of electricity, city gas, LPG, kerosene, coal, others and total amount of household consumption is shown in **Table 1**. In Sendai city gas consumption has been increasing. Future trend of carbon dioxide from household in Sendai is also estimated and shown in **Figure1**. Household carbon monoxide emission is divided into groups such as lighting, motive power and others, cooking, hot water supply, cooling and heating. The carbon monoxide emission from household in Sendai in 1990 is estimated 801 (1000tons/Year), in 2000 is 1,020, in 2010 is 1,049. After 2000 increasing speed will be decreased. Annual increase of total emission between 1990 to 2000 is 3.59% and between 2000 to 2010 it is 1.29%.

A series of wind tunnel Study was also conducted to clarify the relationship between model house locating interval and natural ventilation rate of house. Model for ventilation experiment is shown in **Figure 2**. Tracer gas exhaust point and sampling point of flow out are shown in the figure. Observed relationship between model interval and air change rate are shown in **Figure3**. Pressure differences were measured at four pairs which showed in **Figure2** and **3**, WW-LW, WW-LR, WR-LR and WR-LW. Air change rate per hour decreases as model interval decrease due to the decrease of pressure difference especially at wall point measurement between windward wall and leeward wall (WW-LW). On the contrary when air comes from windward roof air change rate per hour showed small difference against the changes of model interval (WR-LR).

### 4. Summary

Regional characteristics of the thermal performance of the houses and the occupant's behavior in winter time was analyzed focusing on Tohoku district and Sendai area. Comparison study with the result which observed ten years before showed living quality of Tohoku district is improving.

Statistical analysis to clarify the energy consumption trend from residential sector in Sendai and future emission estimation was conducted. Future trend of carbon dioxide from household in Sendai is also estimated. Annual increase of total emission between 1990 to 2000 is 3.59% and between 2000 to 2010 it is 1.29%.

Wind tunnel Study was conducted to clarify the relationship between model house locating interval and natural ventilation rate of house. Air change rate per hour decreases as model interval decrease due to the decrease of pressure difference especially at wall point measurement between windward wall and leeward wall. When air comes from windward roof air change rate per hour showed small difference against the changes of model interval.

Table 1. Energy consumption trend from residential sector in Sendai (Mcal/Household/Year)

	Electricity	City gas	LPG	Kerosene	Coal	Others	Total
1978	2,216	2,508	1,670	4,157	0	15	10,567
1979	2,260	2,422	1,913	3,137	72	52	9,855
1980	2,176	2,331	1,634	3,516	6	70	9,733
1981	2,191	3,001	1,182	3,265	0	60	9,699
1982	2,149	3,012	938	3,241	0	72	9,411
1983	2,004	3,218	1,351	3,464	0	91	10,128
1984	2,352	3,598	977	3,454	30	21	10,433
1985	2,244	3,366	1,086	3,632	0	74	10,403
1986	2,276	3,914	902	4,324	38	18	11,471
1987	2,405	3,771	887	3,786	23	0	10,871
1988	2,348	3,838	772	3,387	76	0	10,421
1989	2,355	3,660	1,055	2,744	0	0	9,814
1990	2,336	3,824	806	2,998	0	0	9,964
1991	2,591	3,948	788	2,955	0	0	10,282
1992	2,806	4,068	1,057	3,389	0	0	11,320

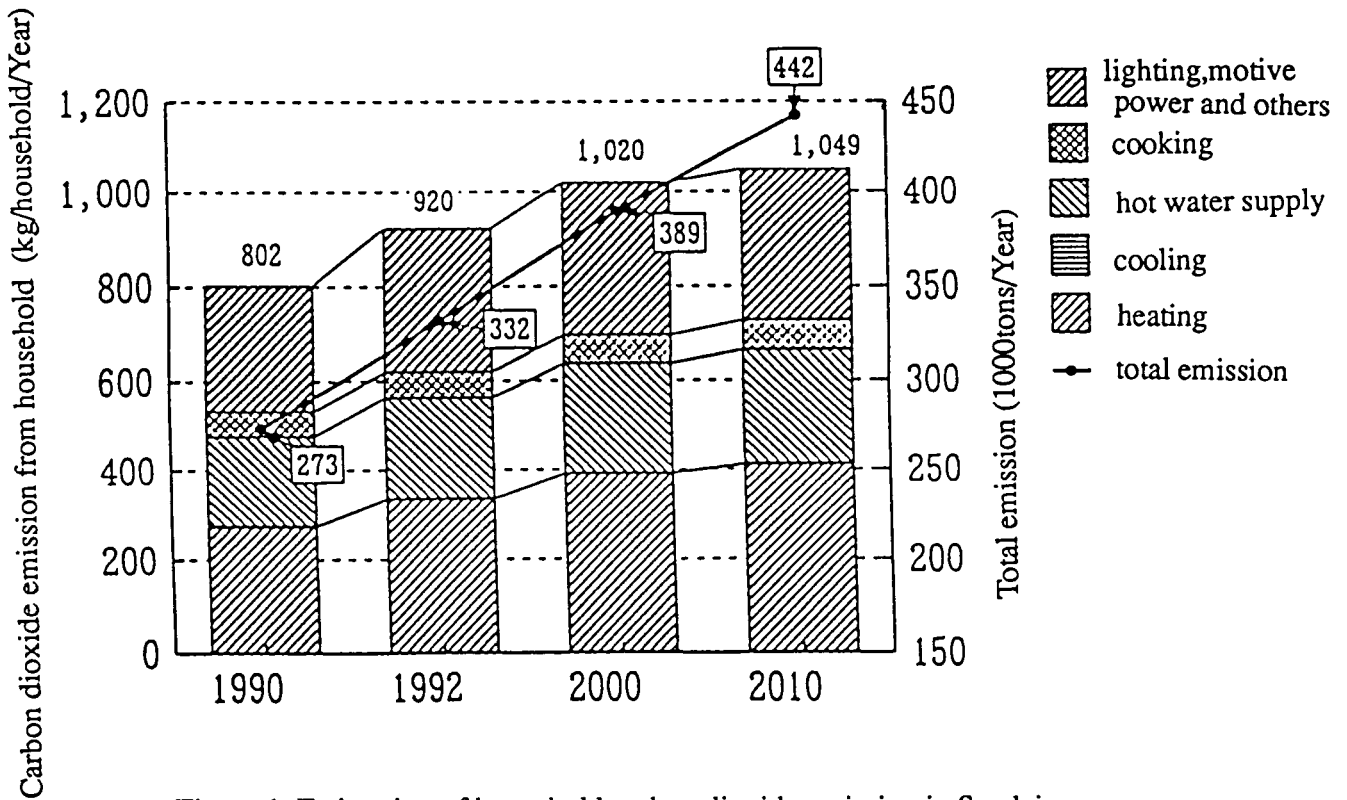


Figure 1. Estimation of household carbon dioxide emission in Sendai

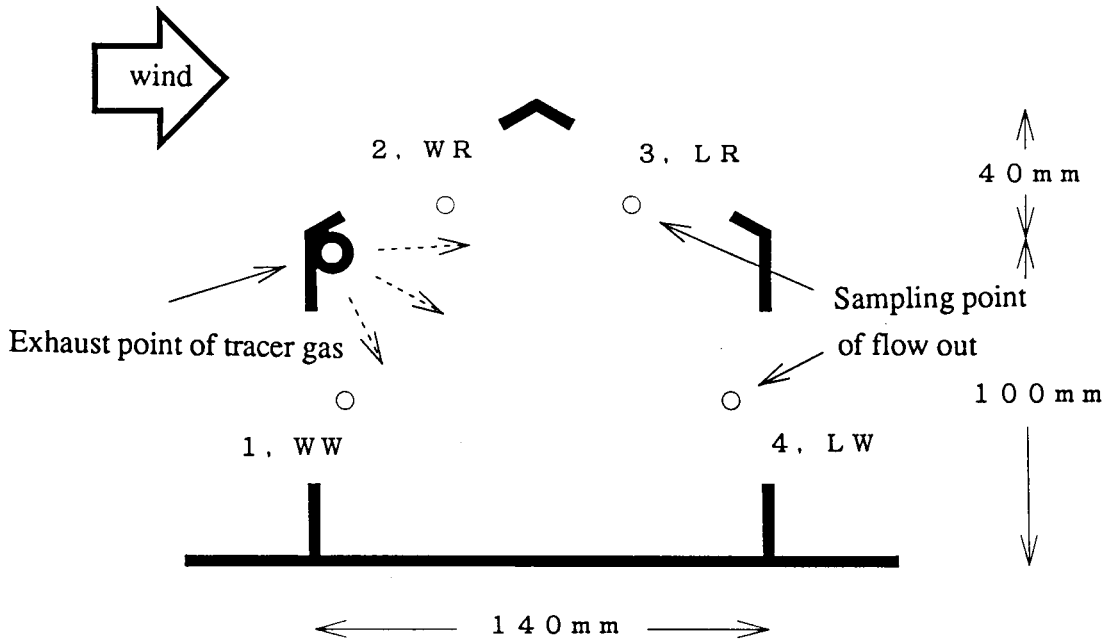


Figure 2. Model for ventilation experiment

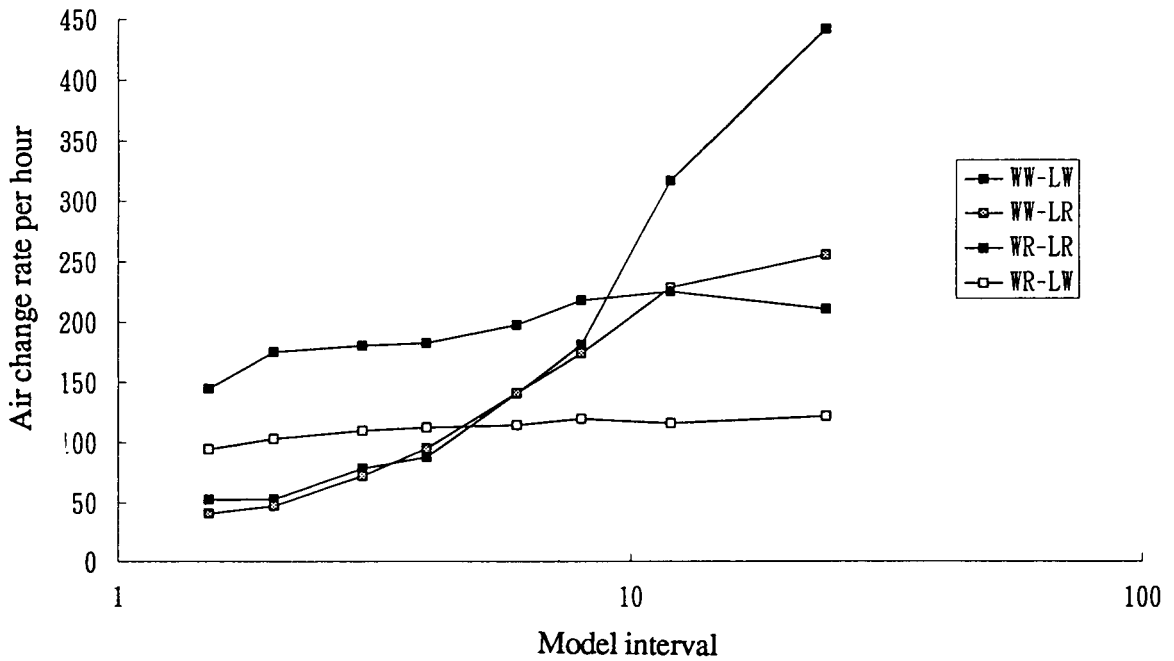


Figure 3. Relationship between model interval and air change rate