B-14.4.1 Analysis of Carbon Dioxide Emission from Residential and Commercial Sector

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Total Budget for FY1990-FY1993 32,959,000 Yen (FY1993; 9,256,000 Yen)

Abstract

As the target for stabilizing greenhouse gas emission is set both nationally and internationally, concrete countermeasures to reduce the greenhouse gas (GHG) emission should be urgently assessed, for all sectors in the society. Especially, energy consumption from the residential and commercial (R&C) sector has been rapidly increasing for recent years. Countermeasures for this sector are really important to reduce overall emission of GHG.

The purpose of this research project is first to compile systematic inventory of the carbon dioxide (CO_2) emission from the R&C sector, second to identify possible countermeasures to reduce the emission, and third to assess various countermeasures from comprehensive viewpoints including effectiveness, cost performance, safety, public acceptance and difficulties of technological innovation.

We clarified the trend and the structure of CO_2 emission based on the energy balance statistics and developed the input-output analysis method to analyze them from the viewpoint of final demand. Moreover, we analyzed the CO_2 emission from the R&C sector through the consumption of non-energy commodities. On the other hand, based on a questionnaire survey, we estimated the amount of CO_2 reduction by household actions to reduce the emission and analyzed factors inhibiting their actions. About half of the CO_2 emission in Japan has a relation with consumption expenditures of household, it is important to take countermeasures in the sector based on energy-saving and resources-saving.

Key Words Carbon Dioxide, Energy Saving, Life Style,Household Expense, Questionnaire Survey

1.Introduction

The global warming is recognized as a highly probable phenomenon in the near future. The government of Japan established the "Action program to arrest global warming" in October 1990 and the Framework Convention on Climate Change was adopted at the "Earth Summit" to stabilize global warming. Under this circumstance, concrete countermeasures to reduce the greenhouse gas (GHG) emission should be urgently assessed, for all sectors in the society. Especially, energy consumption from the residential and commercial (R&C) sector has been rapidly increasing for recent years. Countermeasures for this sector are really important to reduce overall emission of GHG.

2.Research Objective

The purpose of this research project is first to compile systematic inventory of the carbon dioxide (CO_2) emission from the R&C sector, second to identify possible countermeasures to reduce the emission, and third to assess various countermeasures from comprehensive viewpoints including effectiveness, cost performance, safety, public acceptance and difficulties of technological innovation.

3.Research Method

In the first year of this project, the amount of CO_2 emission from the R&C sector for past 25 years with disaggregation by fuel type and by purpose of its use was estimated based on the energy balance statistics. The production processes of basic raw materials like steel or aluminum and accompanying energy consumption were also investigated to estimate the indirect emission of CO_2 through the consumption of commodities made of these materials.

In the second year, we continued the study on systematic inventory of CO_2 emission and started the study on identification and evaluation of countermeasures. Furthermore, we investigated the indirect emission by household through the consumption of non-energy commodities. By applying an input-output analysis (IOA), CO_2 emission intensity per unit output was calculated for every sector's products, then the emission for production was distributed to the final demander of products. On the other hand, we listed up 56 types of actions that were thought to be practicable by household as countermeasures for CO_2 reduction. In order to evaluate the effectiveness of these countermeasures, public acceptance for every action was investigated by a questionnaire survey and reduction rate in CO_2 emission by each action was also estimated.

In the third year, we continued the IOA more in detail for past 15 years and by combining the calculated emission intensity and data extracted from the survey on household expenditures, relationship between emission structure and attributes of family was analyzed. On the other hand, possible reduction of CO_2 emission by household actions on daily life was estimated based on the previous questionnaire survey. In addition, factors inhibiting the public acceptance of these actions were also analyzed.

In the final year of the project, we extended the IOA so as to include influences by imports and exports to estimate the overall emission which Japan concerns. Suppose imported commodities have the same emission intensities as domestic ones, we estimated the amount of CO_2 emitted when imported commodities were produced in abroad. Then we compared these two kinds of CO_2 emission, where one is CO_2 involved in exported commodities and another CO_2 in imported goods. On the other hand, we analyzed household expense data from 1989 National Survey and Family Income and Expenditure compiled by Statistics Bureau of Management and Coordination Agency by attributes of family more in detail, from the viewpoint of relation between the life style and factors of energy consumption by household. Moreover, in order to evaluate the effectiveness of CO_2 reduction by recycling resources, we analyzed the material flow of steel by the IOA.

4.Results and discussions

(1)The inventory of CO_2 emission by sector and by origin and positioning of the R&C sector

In 1990, the R&C sector directly emits 34Mt-C, which occupies about 12% of total emission from fuel combustion. In addition 37Mt-C from electricity use and 8Mt-C from energy conversion is attributed to the final energy consumption by the sector. The emission from the R&C sector was consistently increasing from 20Mt-C in fiscal year (FY) 1965 to

71Mt-C in FY1990 and its share was going up from 17% to 23%. From the viewpoint of purpose of fuel use, in particular, the indirect emission through electricity use as motive power and lighting has remarkably increased and it occupies about half of total emission in the R&C sector. After the first oil crisis, while the emission from the industrial sector was stable or slightly decreasing, the emission from the R&C and the transport sector are increasing except during the period when the oil price was very high after the second oil crisis.

As countermeasures in the R&C sector to cope with global warming, the important problem is how to decrease electricity consumption.

(2)Analysis of CO_2 emission structure by the IOA

The result of the IOA with about 400 sectors from the viewpoint of final demand showed that consumption expenditure of household accounts for approximately half of the total emission. The sum of the direct emission by consumption of gasoline by private car, kerosene or city gas and indirect emission through electricity consumption occupies 20% of national CO_2 emission and about 30% of total is emitted through the consumption of non-energy commodities and services. Moreover, the emission by household has been continuously increasing for past 15 years. On the other hand, we estimated the amounts of CO_2 involved in commodities imported to and exported from Japan. As a result, the total of foreign trade from 1975 to 1985 showed a favorable balance and from 1985 to 1990 the situation has reversed. If we took the difference in energy efficiency between industries in Japan and those in other countries into consideration, the amount of CO_2 imported will be much larger.

Above results indicate that when we think about countermeasures, we should take such a viewpoint into account.

(3)Analysis of actions people taking in their daily lives and their inhibiting factors

1 Estimation of the amount of CO_2 reduced by 23 actions

According to above results, 56 actions which people can take in their daily lives are listed up. To make their feasibilities clear, first, we carried out a questionnaire survey by mail on 1,000 residents who live in two cities in Kanto Plain Region. Next, we estimated the amount of CO_2 reduced by 23 actions in above 56 actions. The result is shown in figure 1. Total amount of 'possible' reduction is estimated as 6Mt-C, 2% of the national emission. Adding 'partly possible,' 15Mt-C, 5% was thought to be reducible.

2 Analysis of factors inhibiting people to take actions

Applying factor analysis method to 10 expected factors from the survey in each 7 action group, 10 expected factors are integrated 4 axis (cost/time consuming, sanitary reason, social norms, and preference). For the most effective action, for example, as for "Building an insulated house," cost is a main inhibiting factor, and as for "Driving an efficient car," preference is a main factor.

The relationship between the attributes of household and the feasibility of each action was also significant. Self-Employed/professional service household and Rural household, of which housekeeping person be older than other groups, are more likely to comply with these actions, and Employed households, which are more likely to move residents and usually commute long way to their company compared to other family categories, are difficult to follow these actions, especially in everyday life patterns and house insulation. Bigger families are also difficult to take actions though housekeeping person be older than other groups.

3 The analysis of energy consumption by household

To analyze the CO_2 emission by household, we investigated energy consumption and household's characteristics using data from 1989 National Survey and Family Income and

Expenditure complied by Statistics Bureau of Management and Coordination Agency, from the viewpoint of relationship between energy consumption and the life style. Figure 2 shows the relationship between income class and electricity consumption based on diffusion rate of each electric appliance. The increases of bigger refrigerators (300 liters and over) and larger televisions (20 inches and over) are largely contributed to higher electricity consumption. We then divided whole samples into two categories -- households that live in an apartment or in a detached house, and made regression analysis to explain total energy consumption (kilo calorie based, including electricity, gas, oil, coal, etc.) by household's characteristics and climate of each residential region for each category group. Income, number of members in a household, and daytime are significant variables for both categories. Using solar water heating system is also significant for the sample group that live in a detached house. Energy reduced by a solar water heater is estimated 102Mcal/month from regression coefficient. This figure is approximately 70% of its official capacity.

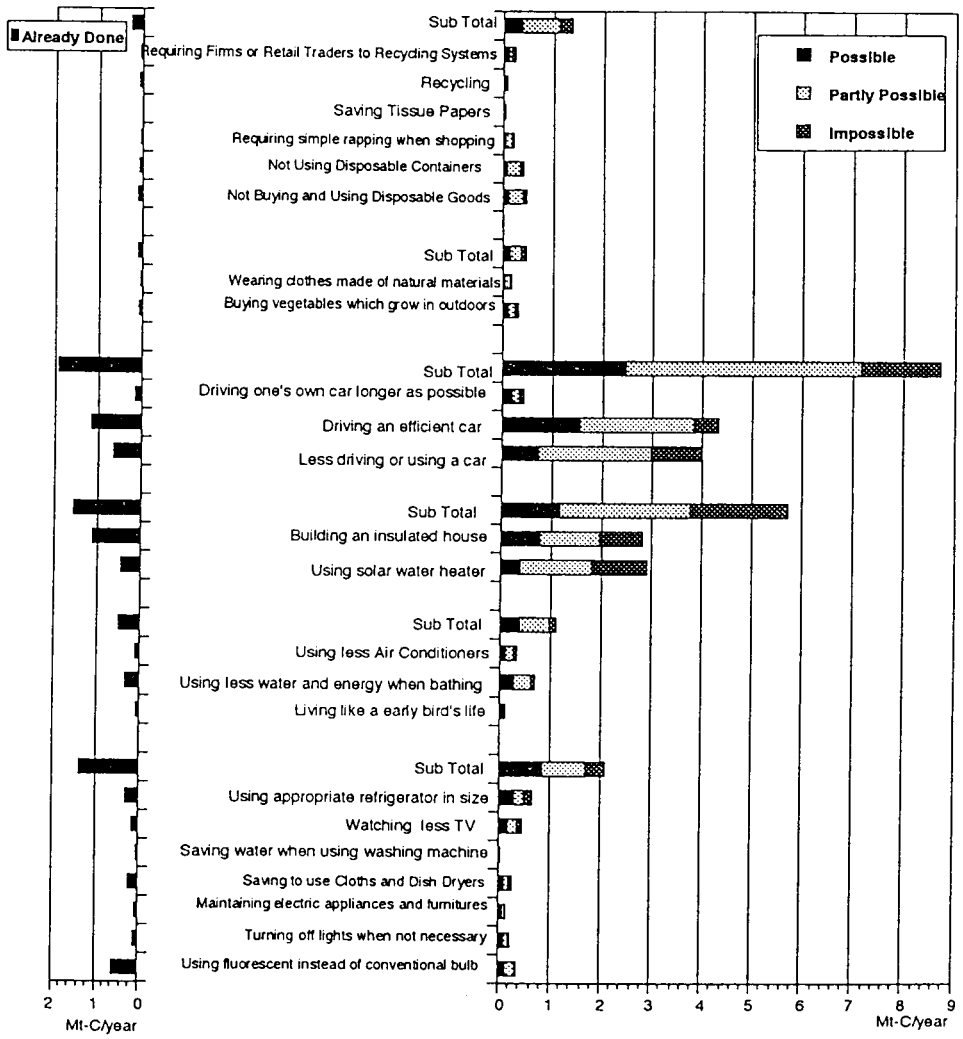

Figure 1. The estimated reduction of CO_2

(4)Estimation of CO_2 reduction rate by recycling resources

We carried out the IOA by picking up steel instead of CO_2 and made material flow table of steel. In Japan in 1985 about 130 Mt-steel was supplied or consumed and of which 50 Mt-steel was exported and almost the same amount was accumulated in the domestic fixed capital.

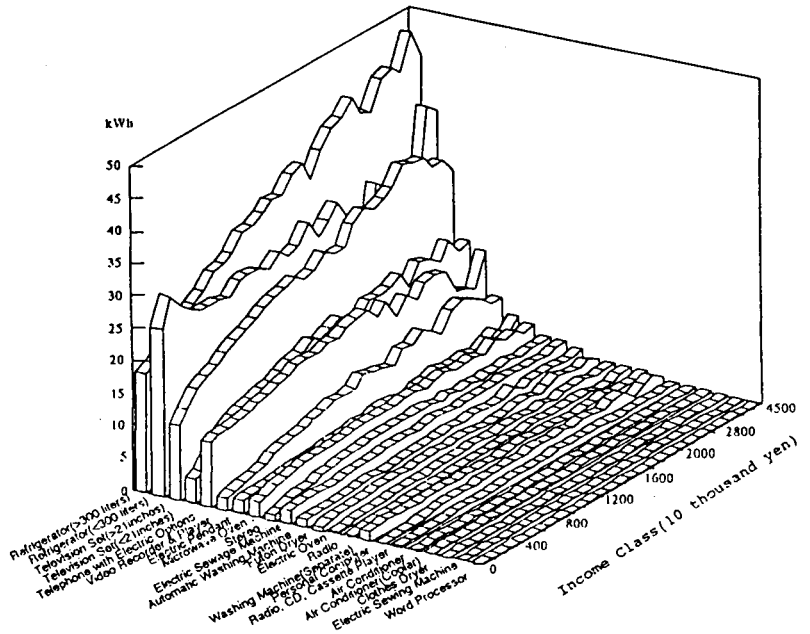

Figure 2. Energy consumption by electric appliances in houses

About 10% of total was consumed as commodities in private consumption expenditures. As this sector includes motor vehicles whose about 70% is steel, the recyclable amount of steel from other goods like steel bottles, refrigerators or televisions seems to be not a lot. Though there are many rooms to promote the recovery of such goods, the amount of steel included in those goods is not a lot. From the viewpoint of reduction of CO_2 emission, it is important to focus on the steel recovery from houses, buildings and infrastructures.

5.Conclusion

We clarified the trend and the structure of CO_2 emission based on the energy balance statistics and developed the IOA method to analyze them from the viewpoint of final demand. Moreover, we analyzed the CO_2 emission from the R&C sector through the consumption of non-energy commodities. On the other hand, based on a questionnaire survey, we estimated the amount of CO_2 reduction by household actions to reduce the emission and analyzed factors inhibiting their actions. As about half of the CO_2 emission in Japan has a relation with consumption expenditures of household, it is important to take countermeasures in the sector based on energy-saving and resources-saving.

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