B-14.1 Development Of Evaluation System For Technical Measures

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Abstract The objective of this 4-year research project is to develop analytic tools designed for evaluating technical countermeasures to cope with global warming. We have evaluated alternative technologies such as cogeneration, energy efficiency improvement and automobile manufacturing, using the following techniques:
1) The element separation method
2) Input-output analysis of energy saving technologies for various industries
3) Optimization model for cogenerator's behavior
4) Supply curve of conserved carbon in the residential sector.
The methodologies developed could be applied to the all sectors of the economy.

Key words Reduction of CO2, Technology evaluation, Input-output analysis, Cogeneration, Energy efficiency

1. Introduction

The global warming problem gas recently attracted considerable attention, and gas developed one of the most important issues in the world. Some countries gave already announced specific proposals for the reduction of GHG emissions. This suggests to us the increasing necessity of precise analyses of the measures for mitigating global warming.

The objective of this study is to develop systematic methods for the evaluation of policy options to mitigate global warming. The methods aim at comprehensive assessments of the economic practicability, the social acceptability, and the technological feasibility of the options by building simulation models.

2. Basic Theory

Fundamental analysis to develop the evaluation system for technical measures to cope with global warming has been made. Two methods for evaluating the countermeasures to

decrease the emission of CO2 were pointed out. The one is the element separation method where the cause of CO2 emission is attributed to three factors, the other is the usage of the modified energy-economy model.

The purpose of the present project is to develop the evaluation system of technical countermeasures to cope with global warming. The contents of the system are 1)the model to evaluate the effectiveness and the price of the technical countermeasures, 2)the model to evaluate the difficulty of the development of the technology, safety and social acceptability, and 3)the model to evaluate the technology totally.

There are two methods for evaluating the technological measures to decrease the emission of CO2, as follows.

(1) The element separation method - three elements type

In the element separation method, the basic equation is,

$$CO2 = \Sigma CO2i = \Sigma \frac{Ci}{Ei} \frac{Ei}{GDPi} GDPi \qquad (1)$$

Where i is the countermeasures in each sector, C is the emission rate of carbon and E is energy consumption rate. If we assume Xi = Ci / Ei, Yi = Ei / GDPi, Xi indicates the effect of the shift of energy source and Yi indicates the effect of energy saving or the effect of the improvement of energy efficiency.

By differentiating equation (1), The next equation can be obtained,

$$\frac{d(CO2)}{CO2} = \frac{d\,Xi}{Xi} + \frac{d\,Yi}{Yi} + \frac{d(GDPi)}{GDPi} \qquad (2)$$

From equations (1) and (2), the relation between CO2 emission and the growth of economy can be obtained under the correlation of energy efficiency and the effect of energy shift.

(2) Evaluation by modified energy-economy model

Energy-economy model is the model where the concept of energy density is put into the input - output analysis. In the purpose of CO2 analysis, emission rate of CO2 depending on each energy source is taken into account in the energy-economy model.

(3) The items to be taken into the evaluation

There are many items to be taken into the evaluation. Those items are the effect of the reduction of CO2 emission, price, technological difficulty, social acceptance, amount of resources, possibility of the destruction of nature, possibility of the new pollution, safety, amenity, etc.

3. Input-Output Analysis Of Energy Saving Technologies For Various Industries

An evaluation method was developed for assessing the effects of individual

countermeasures for reducing CO2 emissions on Japanese national economy.

The method is based on input-output analysis. Savings of energy and/or materials in industrial sectors are assumed to increase their respective added values, but not to let them lower the prices of their production goods. This assumption means that entrepreneurs are offered an incentive to energy conservation much easier.

A numerical example of this study indicates that a 10% reduction of coal consumption in iron and steel industry leads to the decreases in the annual national consumption of industry leads to the decreases in the annual national consumption of petroleum and coal products by 1.45Pcal and 19.59Pcal respectively. This results in 2 million ton-C of the annual emission reduction of CO2, which corresponds to 0.7% of the present total national emission. The evaluations of the effects of material savings can also be conducted in the same way, and coupled with those of the energy savings they can provide us with a guideline for effective policies to reduce CO2 emissions. For some industrial sectors, however, a slight modification of the computational procedure may be required.

Though the use of the above analyzing method, further detail and extensive evaluations of the counter measures are being considered. The introduction of energy intensity analysis for various industrial products is also under consideration, and the two methods are to be compared with each other.

4. Optimization Model For Cogenerator's Behavior

We focused on impacts of wheeling on behavior of cogeneration plant and energy efficiency. Wheeling is expected to enable auto-producers to send extra electricity to other users. Analytical model of cogeneration, which describes the behavior based on maximizing its welfare, led to optimum conditions of marginal value for electricity and heat and a condition where wheeling is preferable.

5. Cogeneration Market Penetration Potential

(1) Commercial Cogeneration

In Japan, installed capacities of CGS have been growing since 1985. As of March 1994, there were 961 cogeneration installations for commercial uses in Japan. These facilities provided a total power generating capacity of 476 MW. For reference, 2318 MW for industrial uses.

The Cogeneration Research Society of Japan has estimated the market penetration potential for commercial cogeneration. Based on projected population estimated in 1992, upper bound of potential cogeneration was revised; projection of 5200 MW by the year 2000 and that of 6300 MW by the year 2010. Furthermore, the realization factor was estimated based on actual installed capacity in 1980-1990, using logistic curve fitting. Here the realization factor is defined as a ratio of actual installed capacity to potential. Projected installed

capacity of commercial cogeneration is 2800 MW in 2000 and 6000 MW in 2010.

(2) Industrial Cogeneration

For industrial applications of cogeneration, projected installed capacity of each industrial class was estimated as follows:

installed capacity=electricity demand*(self generation/total demand)*(cogeneration/self generation)/utilization factor

Electricity demand function for each industry was estimated as follows:

ln E=ln a+b(t-1980)+c ln GNP

E: electricity demand, t: time

Self generation ratio and cogeneration ratio were fitted using time trend. Three cases were defined to reflect different GNP growth rates; 1,2,3%.

GNP growth rates	Projected installed capacity in 2010
1%	6050 MW
2%	7800 MW
3%	10800 MW

6. Supply Curve Of Conserved Carbon In The Residential Sector

Reducing energy consumption is one strategy to reduce carbon emissions. We estimate the potential CO2 savings available from electricity conservation in the residential sector in Japan through 2010.

We estimate the national energy savings from replacement of typical energy-consuming devices with high-efficiency equivalents. We also quantify the savings from shell improvements in existing and new buildings.

We evaluate energy conservation potentials through:

1) calculation of energy savings for specific technologies;
2) simulation of energy impacts of building shell measures;
3) estimation of costs of efficiency measures;
4) projection of technically feasible penetration of these technologies.

Assumptions

Some of key assumptions behind our estimates of conservation potential are:

- Frozen efficiency baseline in 1990
- Real discount rate of 7 %

End uses

- Increase shell insulation:
  - New detached house: 100 mm glass wool+double grazing
  - New apartment: 25 mm polystyrene foam+double grazing
  - Existing building: double grazing, 5%/yr penetration.
- Multi-function heat pump
- Solar system
- Solar hot water heater
- Inverter-type fluorescents
- Liquid crystal TV

Supply curve of conserved energy

The result are presented as supply curves of conserved energy. Each measures appears as a step on the supply curve, with a cost of conserved energy(CCE) plotted against its nationwide energy savings. The 1990 average price of Japan residential energy was 17.0 yen/Mcal. Total energy savings below 17.0 yen/Mcal are about 108 Pcal in 2010 (17% of our frozen efficiency projection of 620 Pcal).

Supply curve of conserved carbon

Supply curves of conserved energy are translated into supply curves of conserved carbon, as shown in Figure 1. The greatest savings are available through liquid crystal TV, followed by inverter-type fluorescent with a zero cost of conserved carbon. The supply curve of conserved carbon shows that a significant amount (16.3% of our frozen efficiency projection of 192 Megatons CO2) can be avoided at negative costs of conserved carbon.

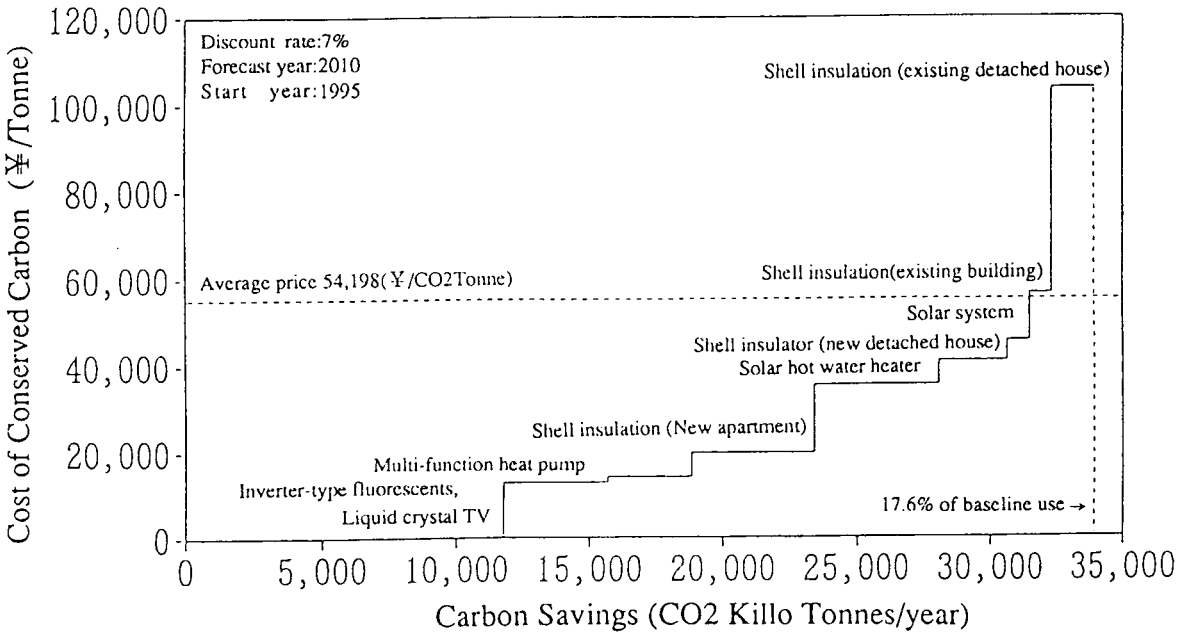

Figure 1 Cost of Conserved Carbon