S-3 Low-Carbon Society Scenario toward 2050: Scenario Development and its Implication for Policy Measures

3. Effects of introducing countermeasures for carbon dioxide emission reduction in urban area（Abstract of the Final Report）

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1. Introduction

Carbon dioxide emissions in transportation, office and commercial and household sector have been increased significantly. Evaluation of potential reduction of carbon dioxide should be done with taking into consideration of urban activity and structure. Simple summation of reduction potential of each technology will overestimate the actual reduction in urban area, because its implementation is limited and there are interactive effects among technologies.

2. Research Objective

The research objectives are to develop the method of evaluation of potential carbon dioxide emission reduction in urban area, and to apply the developed method to cities with various sizes and in various climate conditions in Japan in 2020 and 2050. The unique method of this research is to evaluate the effect of implementing integrated technological options into actual cities for carbon dioxide emission reduction. Prediction of cities in the future target years is also included.

3. Research results

1) Urban scenario and integrated evaluation

In order to assess the potential carbon dioxide emission reduction from all urban areas in the country, individual city-scale assessments carried out to date will have to be expanded to analyze the urban area in the whole country. The objectives of this year lied along with this line. By taking the result from the city scale biomass utilization analysis (i.e. food waste and sewage sludge), the proposed future social scenario A and B in 2050 were considered to draw future visions and carbon dioxide emission reduction potential from bio-gas utilization. The result showed that 3,400GWh/year (approximately 1,840,000t-CO_2/year reduction compared to 2005) could be potentially reduced in both scenario A and scenario B but the figures should be carefully interpreted as the study also

illustrated some critical issues which needed to be further considered in the country scale analysis.

2) Innovation in energy supply to urban area

The influence of the extensive introduction of the residential co-generation systems (CGS) and heat pump (HP) for water heaters were evaluated through the use of 94,000 household energy system models for Japan. The optimal operations of CGS and HP for each household, which has severely fluctuating power and heat load curves, are modeled through stochastic dynamic programming. In order to avoid the influence of the end effect about hot water left in the storage tanks at midnight, convergence calculation of a longer-term simulation were conducted. Moreover, a mathematical fuel cell CGS model based on stochastic dynamic programming was preliminarily developed. The model calculation results indicate that when the value of CO_2 intensity of power system electricity is around 550g/kWh, it is hard to judge which of CGS(gas engine type and fuel cell type) or HP is the more effective. They also indicates that if CGSs or HPs are introduced into 100% of detached houses in Japan, the annual reduction potential of national CO_2 emissions is presumed to be about 5 Mt-CO_2.

3) Energy saving in building sector.

CO_2 emission associated with operation, construction and renovation of office buildings in Japan was predicted by administrative divisions until 2050.

Table 1. Scenarios of case studies and reduction rate of CO_2 emission associated with operation, construction and renovation of office buildings in Japan.

Scenarios of case studies							Reduction rate of CO_2 emission (1990=100%)			
No.	Future society	Scenarios of power supply sector and CO_2 intensity of electricity (kg-CO_2/kWh)					Business as usual case in building sector		Energy saving case in building sector	
				1990	2020	2050	2020	2050	2020	2050
A1	A scenario	1	No change after 2005	0.421	0.390	0.390	-12%	-34%	-12%	-46%
A2		2	Energy Technology Vision 2100 by METI	0.421	0.315	0.120	-26%	-63%	-26%	-64%
B1	B scenario	1	No change after 2005	0.421	0.390	0.390	-23%	-50%	-23%	-69%
B2		2	Energy Technology Vision 2100 by METI	0.421	0.315	0.120	-36%	-72%	-35%	-81%
M1	M scenario	1	No change after 2005	0.421	0.390	0.390	-18%	-42%	-18%	-52%
M2		2	Energy Technology Vision 2100 by METI	0.421	0.315	0.120	-31%	-68%	-31%	-78%

Scenario A (urban concentration type society: an active, quick-changing, and technology oriented society), scenario B (local decentralized society: a calmer, slower, and nature oriented society), and scenario M (average of scenario A and B) would be assumed as a society image as shown in Table 1. Scenario 1 into which the CO_2 intensity of electric power supply does not change after 2005 and scenario 2 based on the “Energy technology vision 2100” by Ministry of Economy, Trade and Industry, Japan.

The forecast result of the M1 scenario is shown in Table 1. CO_2 emission in 2050 will be reduced by 42% in the BAU case and reduced by 52% in the energy saving case. Moreover, the M2 scenario will be reduced by 68% in the BAU case and reduced by 78% in the energy saving case.

4) Introduction of photovoltaic systems into cities

Electricity supply by introducing roof-top photovoltaic (PV) systems in Japan was predicted based on the forecasted future floor areas of residences and NEDO's roadmap of PV systems. The results indicated that the introduced PV systems could supply about 40 % of the total electricity generated in Japan in 2050 and about 60 % of the total roof area of the residences in Japan was covered by the PV modules.

In order to enable such large-scale introduction of PV systems, problems associated with grid connection must be overcome. Therefore, two types of PV system with a battery, a PV system with a battery isolated from the grid and a grid-connected PV system without a reverse power flow were proposed and evaluated. It was found out that the former system was not feasible from an economical standpoint even if the battery price was reduced to a tenth of the present value. On the other hand, the electricity cost of the latter system could be comparable with the present price of the grid electricity if the battery price be reduced to the same extent, and it would be an effective way to enable introduction of PV systems in large quantity.

5) Urban mobility

In 2004 and 2005, we analyzed the effect of area-based road pricing and optimal job-housing relocation policy on reducing carbon dioxide emission derived from car, using network equilibrium models. In 2006, we estimated the amount of short and single-occupant car trips, which can be replaced with walking and bicycle trips relatively easily, and CO_2 emission from those trips, based on the data of car-owner interview survey of Road Traffic Census. It showed that 5 percent of CO_2 emission from automobiles all over Japan could be reduced if all such trips were shifted to green modes. Also we estimated the potential of CO_2 reduction when each of the two future scenarios developed for whole this project come along with job-housing relocation or reduction of short car trips.

6) Utilization of biomass resource and sewage heat in urban areas for energy saving in cities

The potential of bioethanol production from wooden component of construction waste and cultivated biomass was estimated in the whole Japan. From wooden component of construction waste, around 3.0 million-kl (60-70 PJ) of bioethanol can be produced in year 2050, and it corresponds to 3% of gasoline consumption in Japan (2002). From cultivated biomass, such as energy crop and rapid growing tree, around 4,300 PJ can be supplied as bioethanol, and its potential is much higher than wooden component of construction waste. On the other hand, the potential of sewage heat usage as a source of district heating and

cooling (DHC) was also estimated in the Tokyo Ward area. A simulation model for sewage flow and operation of DHC was developed based on spatial information in the Tokyo Ward area, then 137 thousand ton of CO_2 can be reduced for a year by installing 320 DHCs used sewage heat.

7) CO_2 emission change by the improvement of automobiles in cities

A method of the input-output analysis for physical distribution is proposed in this study. Using "Physical Distribution Census" published by National Land and Transportation Ministry, we developed the method to calculate the physical distribution induced by a unit of final demand and the physical distribution derived by a unit of production. We applied this method to the evaluation of CO_2 emissions in 2050. Using the population scenario in 2050, we calculated the CO_2 emission change from the physical distribution in 2000. Then, we evaluated CO_2 reduction potential of modal shift to ship or train from automobile. If the rate of modal shift is assumed as 40%, CO_2 emission reduction from 2000 reaches approximately 30% and 26% in the population scenario A and B, respectively. This result is promising for the contribution of the environment policy making because the CO_2 reduction potential in the automobile sector is explicitly evaluated.

8) Contribution of CGS, DHC and HP to the potential CO_2 emission reduction in the urban area

This study aims at the estimation of the contributions of distributed power systems to CO_2 emission reduction and cost saving concretely by region of Japan. In our previous work, we picked up a medium city Utsunomiya which locates the center of Japan to evaluate the potential contribution of heat pump (HP), cogeneration system (CGS), district heating system (DHC) and their optimal combination to reduce CO_2 emission. Since demand patterns on heat and electricity vary among consumer types and climate conditions, it is not applicable to evaluate the whole contribution of the above energy equipments to the CO_2 emission reduction for Japan. We applied the method to Sapporo and Okinawa which locate north and south part of Japan and evaluate the potential contribution of them. We found a linear relationship between the ratio of commercial building floor area to total building floor area and potential CO_2 reduction rate in case of full option and HP case in spite of the large difference of climate conditions. Assuming that the relationship between density of residential building area and the distance from the center of the city of Utsunomiya holds in other regions, we evaluate the potential CO_2 reduction of the new energy equipments for 950 Japan cities where 18.6% CO_2 emission reduction potential in total is indicated. Although there remain many issues in our study, this is the first estimation on the contribution of DHC, CGS and HP considering the partial load properties and GIS based detailed building data.

(9) Development of integration tools for sharing knowledge between various actors

We have been designing and constructing a Web-based collaboration platform to support

the achievement of the project goals. Towards the construction of this Web-based collaboration platform, in 2004 we constructed an information platform for knowledge sharing between researchers. In 2005, we implemented interfaces for manipulating the computational models constructed by researchers both inside and outside the group through the Web-based platform. In particular, we used the DOME (Distributed Object-based Modeling Environment) model integration software to construct an environment enabling access of models through the Web-based platform. We integrated the Power Planning and Dispatch Model with models for evaluating energy saving countermeasures in residential and commercial buildings and the effect on reducing electric power demand. We used the integrated system model to calculate the CO_2 emissions for each of the nine major power companies in Japan and showed how we can calculate the total CO_2 emissions from electric power generation for Japan. Summary of work are:

-Construction of an integrated system model incorporating the Power Planning and Dispatch Model together with the residential and commercial sector models using the DOME model integration tools

-Extension of the Power Planning and Dispatch Model to cover the nine major electric power companies in Japan and evaluate the total CO_2 emissions from Japan

-Integrated analysis and evaluation of Japan CO_2 emissions using the Power Planning and Dispatch Model extended to cover the nine major electric power companies in Japan together with the residential and commercial sector models

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