An Analysis of Long-term CO_2 Emission Reduction Potential and Final Energy Demand Structure in the Japanese Commercial Building Sector by a Bottom-up End-use Energy Demand Model

Background

CO_2 emissions from the commercial building sector in Japan have been increasing year by year as the commercial building stock grows. It is expected that, as the national economy develops, the commercial building sector will become a larger part of the economy and so it will use more energy and release more CO_2 emissions in the future as well. Under the energy conservation law revised in FY2008, designated subjects of energy management were changed from by factory to by enterprise, meaning that about 50% of the commercial building stock becomes control subjects under the revised energy conservation law, as opposed to only 10% before the revision. There is a great need to reduce sectoral CO_2 emissions, however, so far not many studies have quantitatively analyzed the potential and cost effectiveness of introducing CO_2 emission reduction technologies into the commercial building sector.

Objectives

The purpose of this study is to illustrate possible CO_2 emission trajectories toward FY2030 for the commercial building sector, using a regional and sectoral bottom-up energy demand model. Economic assessment as well as CO_2 emission analysis is performed to find out what kinds of end-use energy technologies for air conditioning, lighting, water heating and cooking demands in this sector can contribute to cut emissions the most cost effectively.

Principal Results

1. Reference case: Emissions trajectory with business as usual

To illustrate the emissions trajectory, first, the commercial building stock toward FY2030 is estimated for each region and each building type in line with the governmental demographic and employment projection toward FY2030. The reference case, which corresponds to the emissions trajectory with business as usual, supposes that recent trends of customer's technological choices and autonomous energy efficiency improvements (AEEI) of end use equipments will continue toward FY2030. For example, decentralized heat pump air conditioners are further utilized than at present replacing central air conditioning systems, and fuel shift continues in thermal end uses from petroleum products to natural gas. Figure 1 shows the estimated sectoral CO_2 emission trajectory during FY2000-2030 for the reference case. The sectoral CO_2 emissions increase up to FY2015, has its peak around FY2015 and thereafter decreases until FY2030. The CO_2 emissions increase by 2% in FY2030 compared to the FY2005 level, which reflects slowing down in growth of the commercial building stock and continuously increasing equipment energy efficiency in the coming decades.

2. Policy case: Impact of introduction of CO_2 emissions reduction technologies

The policy case supposes the two following measures to cut emissions more than the reference case: (a) Accelerated improvements of end-use equipment efficiency and lowering of equipment cost are made through further research and development efforts by manufacturing industries, (b) Building owners are encouraged to install a set of energy saving and fuel switching technologies to make the per floor space CO_2 emission the lowest when their buildings are newly constructed or retrofitted.

(1) Sectoral CO_2 emission reduction potential and final energy demand structure change

In the policy case, the sectoral CO_2 emissions can be made reduced by up to 20% and the final energy consumption can be reduced by up to 26% in FY2030 compared to the FY2005 level by introducing a set of end-use energy saving and fuel switching technologies as shown in Figure 1. This emissions reduction potential corresponds to about 1.3% of the FY1990 emissions level of Japan. The sectoral CO_2 emissions reduction of 20% leads to an increasing share of grid electricity of about 70% in the final energy demand in FY2030, which is induced by further utilization of grid electricity in end uses, especially water heating and cooking as shown in Table 1. When the CO_2 emissions are reduced by 15% compared to the FY2005 level, grid electricity has a share of 55% and natural gas has a share of 36% in the final energy demand, since there are some cases when fuel switching in water heating from petroleum products to natural gas is less expensive than introduction of electric heat pump water heaters.

(2) CO_2 emissions reduction cost

The sectoral CO_2 emissions reduction of 20% in FY2030 requires CO_2 emissions abatement cost of about 1 trillion yen annually, the total sum of initial cost of 540 billion yen and energy cost of 460 billion yen, which should be paid by commercial building owners and tenants. When the CO_2 emissions are reduced by 15%, 780 billion yen annually needs to be paid, the total sum of initial cost of 80 billion yen and energy cost of 700 billion yen. The sectoral CO_2 emissions reduction of 20% costs office buildings, retail stores and restaurants about 200 to 350 billion yen annually for each.

Future Developments

This study will be extended to deal with other CO_2 emissions reduction technologies for commercial buildings such as thermal insulation improvements of buildings and on-site utilization of renewable energy resources to build up a comprehensive approach to the sectoral emission impact and cost analysis.

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Reference

M. Takahashi and H. Asano, 2008, “An Analysis of Long-term CO_2 Emissions Reduction Potential and Final Energy Demand Structure in the Japanese Commercial Building Sector by a Bottom-up End-use Energy Demand Model”, CRIEPI Report Y07039 (in Japanese)

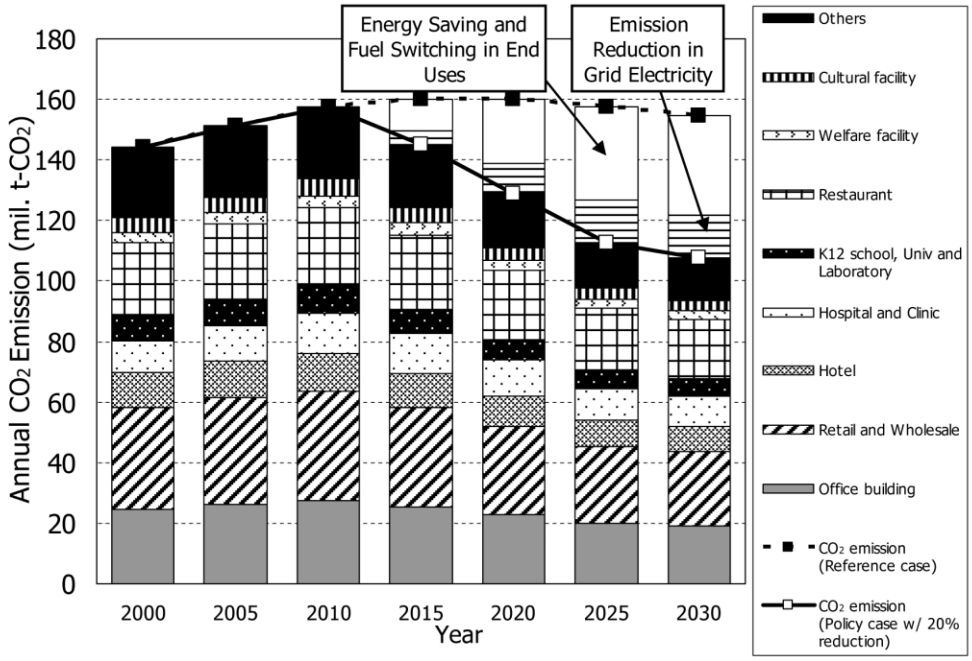

Fig.1 Estimated CO_2 emissions from commercial building sector: Reference case and Policy case

In the policy case, the sectoral CO_2 emissions are reduced by up to 20% in FY2030 compared to the FY2005 level by introducing a set of end-use energy saving and fuel switching technologies. Lowering the CO_2 emissions factor of grid electricity from 360 g-CO_2/kWh in FY2010 to 300 g-CO_2/kWh in FY2030 by generating more low-carbon emitting electricity gives an additional sectoral CO_2 emissions cut of about 10%, coming to a total sum of the CO_2 emissions cut of about 30% in FY2030.

Table 1 Estimated CO_2 Emissions Reduction FY2030 by Technology (Unit: million ton-CO_2)

	All generators-averaged emission factor		Fossil fuel-fired generators-averaged emission factor
	15% emission reduction	20% emission reduction	20% emission reduction
Accelerated COP improvement of electric and gas heat pump air conditioner	4.4	4.4	7.8
Spread of light emitting diode(LED) lighting system	5.0	5.0	8.4
Spread of building energy management system(BEMS)	2.7	6.2	9.9
Switching to electric-powered air conditioning system	1.7	2.1	0.0
Spread of electric heat pump water heater and induction heating(IH) cooker	7.2	10.1	3.1
Fuel shift in water heating	3.0	1.8	2.6
Spread of combined heat and power(CHP) system with highly-efficient generator and high COP heat pump chiller	2.5	3.0	3.2
Total	26.5	32.6	35.0