Air Quality Impact Assessment for Prevalence of Cogeneration Systems − A Case Study for Environmental Concentrations of Nitrogen Oxides within Tokyo's 23 Wards −

Background

Cogeneration systems (CGS) have been installed for commercial use in buildings such as hotels, hospitals and office buildings in Japan to reduce energy consumption and CO_2 emissions. Most CGS operate by internal combustion using gas turbines or gas engines; thus, exhaust gases containing NOx are released from the building's rooftops in urban areas. Accordingly, it is necessary to evaluate the effects of the exhaust emission on the air environment of the surrounding area appropriately.

Objectives

To calculate the ground-level concentrations of nitrogen oxides discharged from cogeneration systems within Tokyo's 23 wards in fiscal year (FY) 2004 and 2020 and to estimate their impact on the surrounding areas;

Principal Results

1. Projection of the total generation capacities of CGS within Tokyo's 23 wards in FY 2020

(1) A bottom-up end-use energy model that assesses the impact of innovative energy technology on future energy demand was used to project the total generation capacities of cogeneration systems that will be installed in the commercial sector by FY 2020.

(2) The total energy capacity of cogeneration systems projected by the model is about 287MW for the standard case in which the energy efficiency of each piece of equipment is assumed to be the same for FY 2004 and FY 2020. On the other hand, the total energy capacity for the improved-efficiency case is 369MW, which corresponds to about 1.5 times the capacity in FY 2004.

(3) We prepared NOx inventories that include information about each of the buildings with installed cogeneration systems using a geographic information system (GIS) to simulate the spatial distribution of ground-level concentrations of NOx.

2. Calculation of the annual ground-level concentrations of NOx discharged from CGS

(1) A GIS-based air dispersion modeling system that can take into account the building downwash effect using commercially available electronic residential maps was applied to calculate the annual average ground-level concentrations of NOx discharged from the CGS within Tokyo's 23 wards.

(2) The calculated maximum values of the annual average concentrations of NOx were 9.8 ppb for the standard case and 10.4 ppb for the improved-efficiency case; these are equivalent to 20.2 % and 21.4 % of the ambient air concentrations, respectively.

(3) The calculated annual average concentrations of NO_2 at FY 2020 meet the environmental quality standard at most of the ambient air pollutant monitoring stations, but some of them exceed the standard.

Future Developments

An atmospheric dispersion model that considers the effects of the atmospheric stability and the heating of the building's surface in urban areas will be developed.

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Reference

A. Sato, et al., 2007, "Air quality impact assessment for prevalence of cogeneration systems," CRIEPI Report V06005 (in Japanese)

Table 1 Installation capacities of cogeneration systems (FY 2004, FY 2020) (Unit : kW)

	Commercial Use (S : Total floor area < 10,000 m^2, L : Total floor area >= 10,000 m^2)											
	Office (S)		Office (L)		Store (S)		Store (L)		Hotel (S)		Hotel (L)	
Gas Engine / Gas Turbine	GE	GT	GE	GT	GE	GT	GE	GT	GE	GT	GE	GT
FY 2004	1,708	224	21,991	17,026	117	28	10,566	0	449	103	6,390	6,200
FY 2020 (standard case)	4,389	224	36,866	24,644	127	28	22,718	0	613	103	7,555	4,259
FY 2020 (improved-efficiency case)	4,903	224	94,820	28,300	185	28	59,976	0	225	103	5,952	619

	Commercial Use						Industrial Use	Total
	Hospital (S)		Hospital (L)		District Heating and Cooling	Others		
Gas Engine / Gas Turbine	GE	GT	GE	GT	GE&GT	GE&GT	GE&GT	
FY 2004	1,921	0	12,958	1,116	103,900	9,636	44,468	240,232
FY 2020 (standard case)	3,939	0	21,926	94	103,900	9,636	44,468	286,941
FY 2020 (improved-efficiency case)	2,946	0	11,098	54	103,900	9,636	44,468	368,859

In the office (L) and the store (L), the number of buildings where the gas engine cogeneration system is introduced increases for the peak load reduction during the summer months.

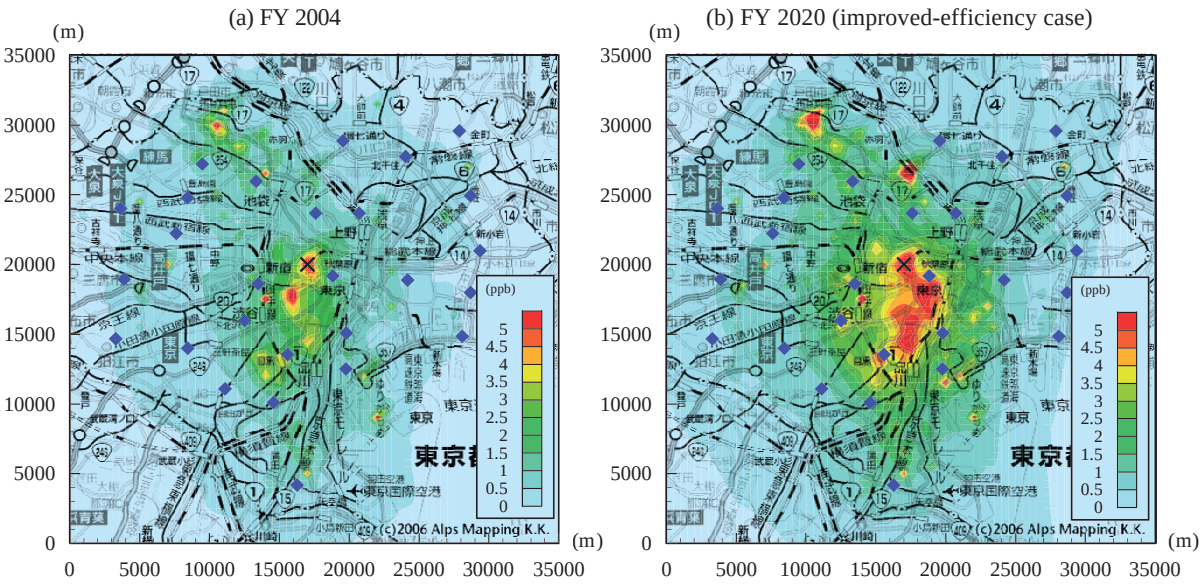

Fig.1 Calculated annual averaged NOx concentrations at FY 2004 and FY 2020.

Calculated concentrations of NOx in the center of Tokyo (the area inside of the JR Yamanote Line), where many cogeneration systems are introduced, were higher than those of surrounding