Air Quality Impact Assessment for the Cogeneration Systems in Urban Area

Background

More than 3,850 cogeneration systems have been introduced as energy-saving equipment for both commercial and industrial uses since the 1980s in Japan. The heat produced when energy is generated can be used for hot water supply and air conditioning, so cogeneration systems are located near sites where the heat is required. Almost all of the cogeneration systems operate by internal combustion, such as gas turbines, gas engines and diesel engines that burn fossil fuel, thus exhaust gases from cogeneration systems contain nitrogen oxides (NOx). The impacts of these emissions on air quality, by taking into account building downwash, must therefore be considered because many cogeneration systems have stacks that are lower than the height of a nearby building in urban areas.

Objectives

To estimate annual emissions of NOx discharged from cogeneration systems based on the results of a questionnaire survey and evaluate the air quality impact of cogeneration systems using an atmospheric dispersion model.

Principal Results

1. Estimation of annual NOx emissions discharged from cogeneration systems

A questionnaire survey and an interview of consumers within the Tokyo metropolitan area were conducted. Questionnaires were sent to commercial and industrial consumers with total power generation capacities of 1,000 kW or more. In the survey, exhaust heights, discharge concentrations of NOx, operation hours, and so forth were determined. On the basis of the results of the survey, it was determined that in many cases discharged NOx concentration levels are approximately 50% of those indicated in the regulations issued by local governments. Moreover, the amount of NOx discharged from all cogeneration systems installed within the Tokyo metropolitan area was estimated to be approximately 1,100 tons/year.

2. Simulation of air quality impact of the cogeneration systems

A Gaussian plume model was applied to compute spatial distributions of concentrations of NOx released from cogeneration systems in urban areas of Tokyo. 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 areas and the annual mean concentrations within that area were 0.6 to 2.5 ppb in most calculation points and the average concentration was 1.6 ppb, which are equivalent to approximately 3.1% of ambient air concentrations. Moreover, there were also areas within the calculation domain that showed concentrations higher than 10 ppb.

Future Developments

An air quality impact assessment on the assumption that more cogeneration systems are installed based on the diffusion scenario in urban areas will be conducted.

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Reference

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A. Sato and Y. Ichikawa, 2004, Estimation of annual emissions of NOx discharged from cogeneration systemsin the Tokyo metropolitan area., Komae Research Laboratory Rep.No.T03009 (in Japanese).

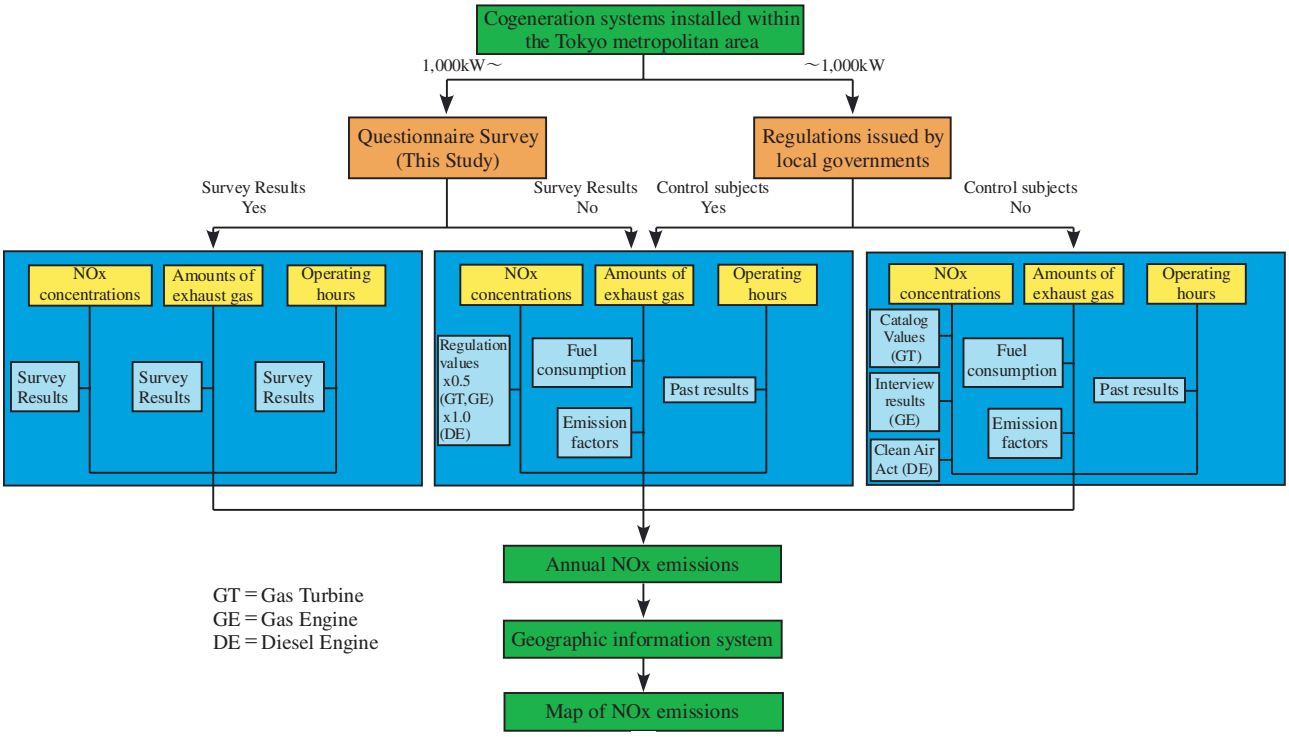

Fig.1 Flow diagram for estimation of NOx emissions

NOx concentrations, amounts of exhaust gas and operation hours using in estimation were established based on the questionnaire survey results.

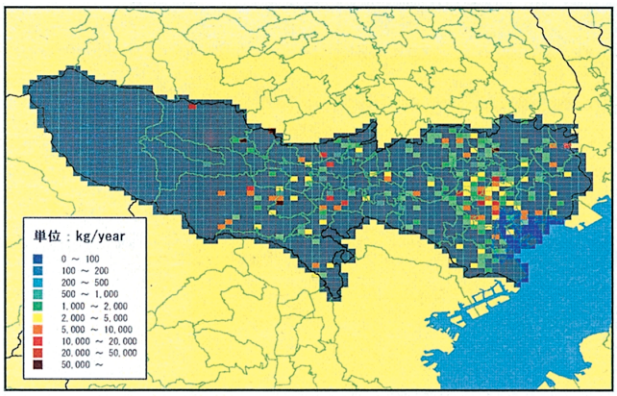

Fig.2 Map of NOx emissions from cogeneration systems

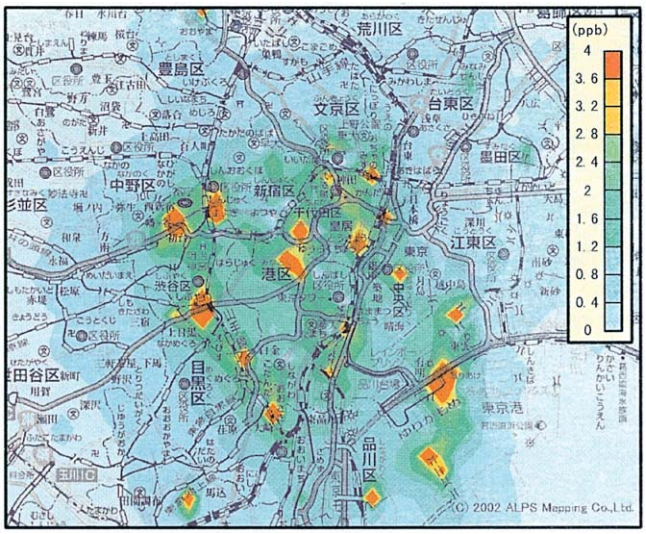

Fig.3 Contour plots of ground-level annual mean concentrations of nitrogen oxides

Table1 Annual NOx emissions (tons/year,2002)

	GT	GE	DE	Total
Commercial	139	266	90	495
Industrial	204	131	271	606
Total	343	397	361	1,101

At the areas along the JR Yamanote Line, such as Shinjuku, Osaki, Hamamatsucho, and Tokyo, the concentrations showed higher values than those of the surrounding areas.