1. Air Pollution and the Traffic System in the City

Main cause of the air pollution in the large cities is the automobile depending traffic system. In this situation, possible counter measures are:

- Reduction of the emission from the automobiles
- Regulation for the traffic, such as the suppression of private car use inducing to the public traffic system

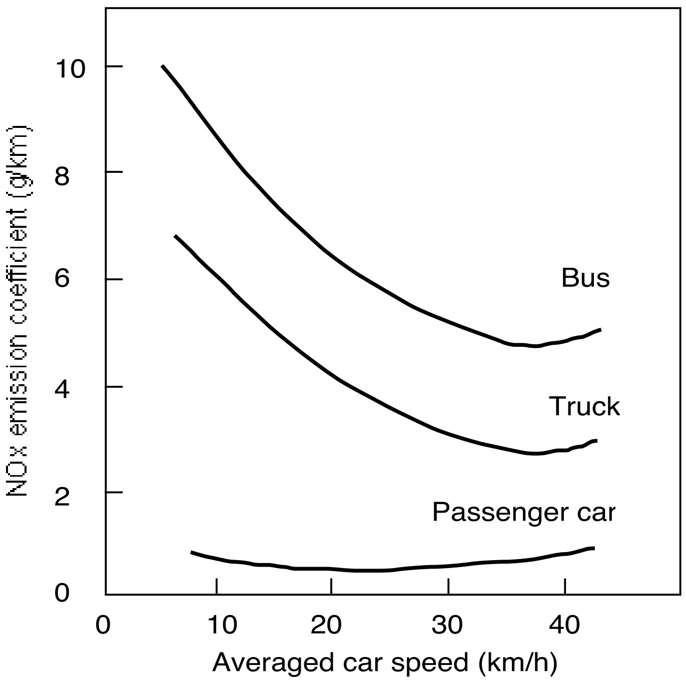
2. Control of the Exhaust Gases from the Automobiles

a. estimation of the total emission

To evaluate the traffic regulations, the estimation of the exhausted mass is required. The estimation of the pollutants mass for a target road can be carried out by following process:

1. Measurement for the **traffic Q_i** with each automobile type **i** and its averaged speed $\mathbf{V_i}$
2. Obtaining the air pollutants **emission coefficients Ef_i** for each automobile type using averaged speed
3. Calculation of the total pollutants **Tp** emission using the equation: **Tp**= Sum ($\mathbf{Q_i \bullet Ef_i(V_i)}$) for **i** ,

where, a table of the relation between the emission coefficients and averaged automobile speed is prepared as followings (On the road, automobiles stop, accelerate, run, and decelerate, however, we can estimate emission coefficient with the average speed in most cases).



mode	amount of exhaust gas	density in the exhaust gas		
		CO	HC	NOx
idling	S	H	M	L
acceleration	L	H	H	H
constant: high	H	L	M	H
constant: low	M	L	M	M
de-acceleration	L	M	H	L

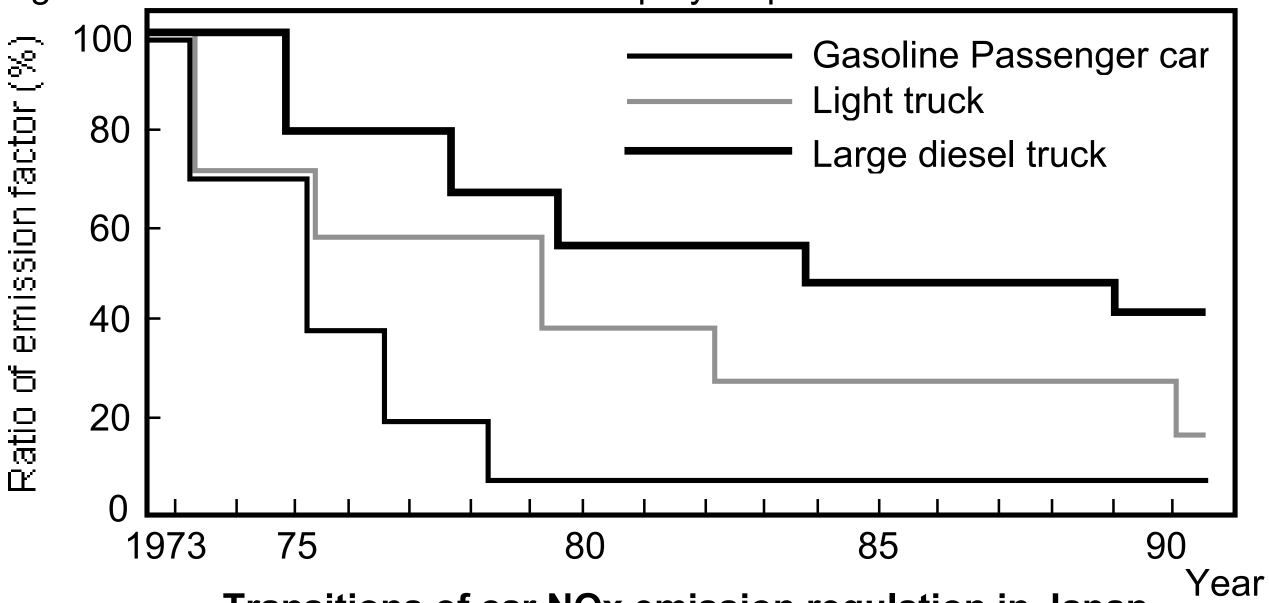
b. Emission controls in US

Control of the emission through improvement of engine combustion could not meet the strict emission standards of the 1970 amendments (10% of 1970 levels by 1975) which is called as the **Muskie Act**.

Automobiles emissions with these controls were highly variable - changing with driving conditions and habits. At the time of the 1970 CAA(Clean Air Act), the technology to reduce emissions after combustion did not exist, and the mandated deadlines were postponed, with interim standards imposed instead. These interim standards were achieved with the use of catalytic converters.

c. Emission controls in Japanese

In 1973, **NOx regulation** was started in conformity wiht the atmospheric pollusion prevention law, and the regulation level has been increased step by step.



Transitions of car NOx emission regulation in Japan

NOTE: In 1973, Honda CVCC engine (lean burn engine) complies with US Muskie Act.

d. Total reduction law for NOx in Japan

Japanese government **raised** the level of **NOx regulation** for the **fixed sources** and the level of **car NOx** regulation, however, **environmental standard for the NOx** concentration has not been satisfied in **megaro-cities**. The cause was estimated the increase of traffic and enlargement of diesel engine cars. Then in 1992, the law "Reduction of the total NOx exhausted from the automobiles in the specified areas" was established.

3. Emission from the Inner Combustion Engines

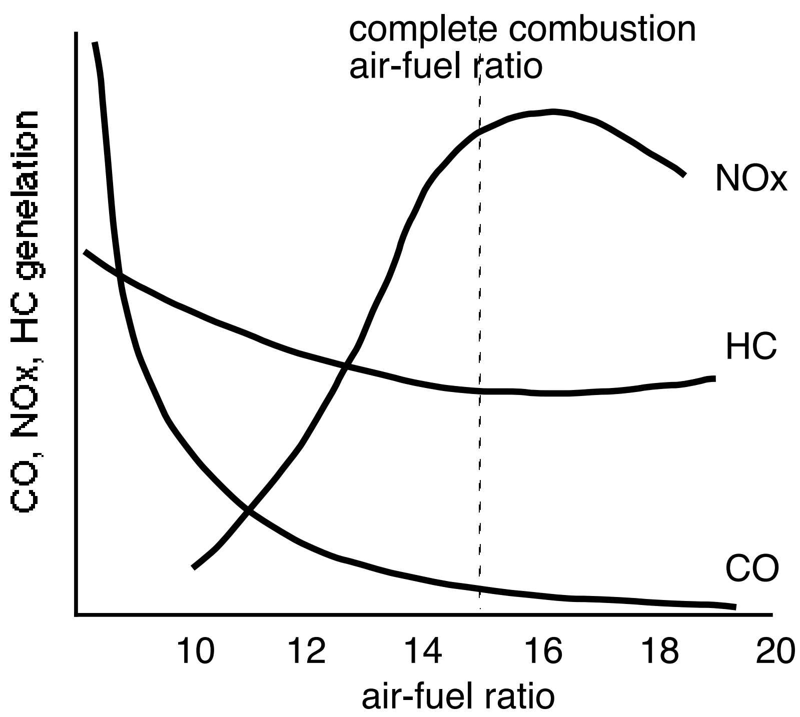
Most traffic systems on the road use the gasoline engines or diesel engines. The exhausted gas from the **gasoline engines** includes **CO, NOx, HC**(Hydrocarbons), and the gas from the **diesel engines** includes less CO but much **NOx and SPM** (Suspended Particulate Matter).

NOx from ether type of engines is generated from the reaction of N_2 and O_2 in the high-temperature combustion cylinder, and 95 % of it is NO and the remainder is NO_2. In general, CO and SPM can be reduced by increasing the combustion temperature, however, the amount of NOx increase on the contrary.

Exhausted **NO** is converted to **NO_2** by the oxidation in the atmosphere.

4. Emission from the Gasoline Engines

Gasoline is primarily a mixture of hydrocarbons (when described as C_xH_y, x : y= 1 : 1.85) that produces energy when ignited in the presence of air. From this reaction, 1735 g of air are required for every 114 g of gasoline for complete combustion - and air-fuel ratio of 15:1. Prior to emission control, much lower ratios were common because they produced maximum power. But these **fuel rich** ratios resulted in incomplete combustion due to insufficient amounts of O_2, leading to the generation of large amounts of CO and hydrocarbons.



a. CO and Hydrocarbons
Industry initially responded to regulation by enhancing the combustion process through the use of lean air-fuel ratios. This did reduce emissions of CO and hydrocarbons, but resulted in increases in NOx emissions.

b. Control of NOx
Unlike emissions of CO and hydrocarbons, control of NOx emissions is more difficult (especially since initial controls of CO and hydrocarbons resulted in higher NOx emissions).

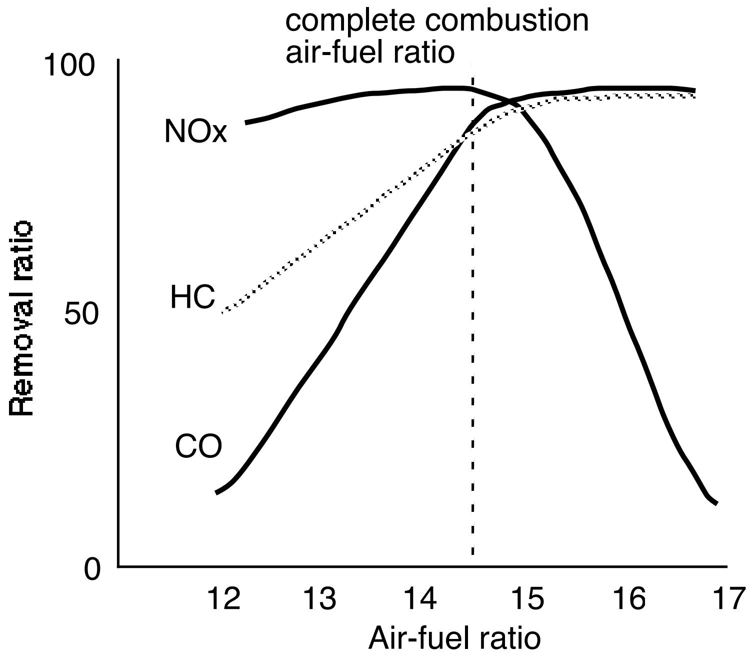
The most effective control measure for the reduction of NOx is the use of exhaust gas recirculation (EGR). A controlled amount of the exhaust gas is recycled back into the combustion chamber. The recycled exhaust absorbs some of the excess energy which would otherwise produce NOx.

c. Catalytic Converters

Catalytic converters are after-devices, reducing emissions by converting the exhaust after it leaves the engine. As with other catalytic cycles, the catalyst participates in the reaction, but they do not themselves undergo chemical conversion.

Catalytic converters use special metals, such as platinum and palladium to convert CO and hydrocarbons to CO_2 and water vapor. Lead poisons the catalyst - this is why cars use unleaded fuel.

However, recent technology has led to the introduction of 3-way catalytic converters that reduce concentrations of NOx as well as CO and hydrocarbons. Lower panel is the relation between the removal ratio and air-fuel ratio when using 3-way catalytic converters.



In this system, the variation of air-fuel ratio must be controlled within plus/minus 0.4. For this control, the system requires O_2 sensor to detect the O_2 density of exhaust gas and the EFI (Electronic Fuel Injection) system.

5. Emission from the Diesel Engines

Diesel engine produce the power combustioning the misted fuel (light oil) injected into the combustion chamber in the state of high-temperature and high-pressure. The fuel burns by the self ignition.

In the diesel engine combustion process, partial oxygen deficiency causes **unburned particles** which bring out the black exhausted gas. To reduce the unburned particles, complete combustion is required, however, higher chamber temperature introduced by the complete combustion yields more production of **NOx**.

The Diesel fuel (light oil) includes **sulfur** (about 0.2 %), then the exhaust gases from the diesel engines include SO_2 and H_2SO_4. These sulfate and the unburned particles interfere the NOx reduction system such as **EGR** (exhaust gas recirculation system) and/or catalytic converter.

a. Control of the exhausted gas of the diesel engines

- Reduction of sulfur in the diesel fuel (to 0.05 %) for adopting the NOx reduction system
- Lowering the combustion temperature to reduce the generation of NOx
- Use of the particle trap for the exhaust gas
- Development of 2 stroke diesel engine (1999 Yamaha)
- Transfer to the gasoline engines

6. Low Emission Automobiles

There are many research/ industrial activities to lower the emission from the automobiles.

a. Low fuel consumption car
- 3 litters car development (the automobile that can run 100 km per 3 litters)
- light weight body car
- Inner combustion/ electric motor hybrid car (optimizing the engine efficiency)

b. Low emission car
- lean burn engine development

c. Zero emission car
- Electric car