6.2 Countermeasure for automobile emission

6.2.1 Overview

Fig. 6.2.1-1 shows the essence of environmental problems caused by automobiles in the city of Tehran, and related countermeasures against them. A circle at the center of the page explains the following eight categories indicating situations related to automobiles in Tehran as follows.

- Road condition
- Geographical and meteorological condition
- Automobile fuel
- Economic activities
- Automobile technology
- Traffic infrastructure
- Automobile user

The outer circle describes sub-categorical situations of those described in the inner circle.

Around the circle area described the present situations including measures being taken in Tehran corresponding to those in the circle. The squares painted red or green explain countermeasure needed to impose the amenities and environments. The countermeasures in red color are technical ones aiming at improvement of hardware such as an engine and gasoline, and those in green color are non-technical countermeasures depending on people's environmental awareness and PR activities, etc.

In the light of circumstances, a countermeasure against deterioration of traffic situations and city environments cannot catch up with rapid increase of traffic.

We have two ways to approach a solution for problems of urban transportation: one is the approach to the supply side such as improvement of traffic facilities or an

effective use of existing facilities, while and the other, the approach to the demand side such as an appeal to individuals' cooperation and people's traffic behavior. In addition to the above ways, we examined issued on a car engine, car fuel, car maintenance, improvement of car inspection systems and a way to introduce a car scrappage program. These proposals are tabled in Fig. 6.2.1-2.

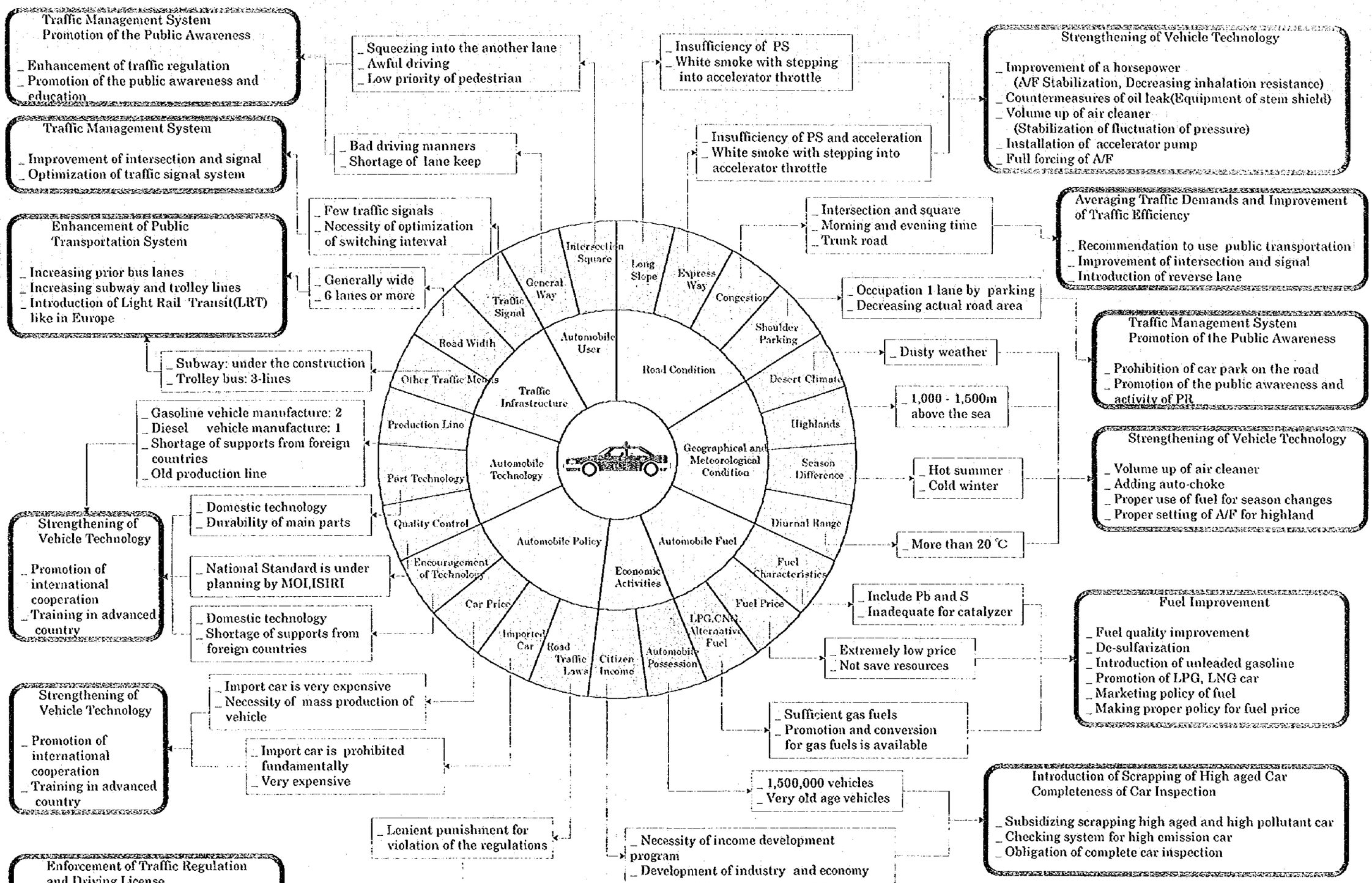


Fig.6.2.1-1 Suggestion for improvement automobiles and their surroundings to control air pollution

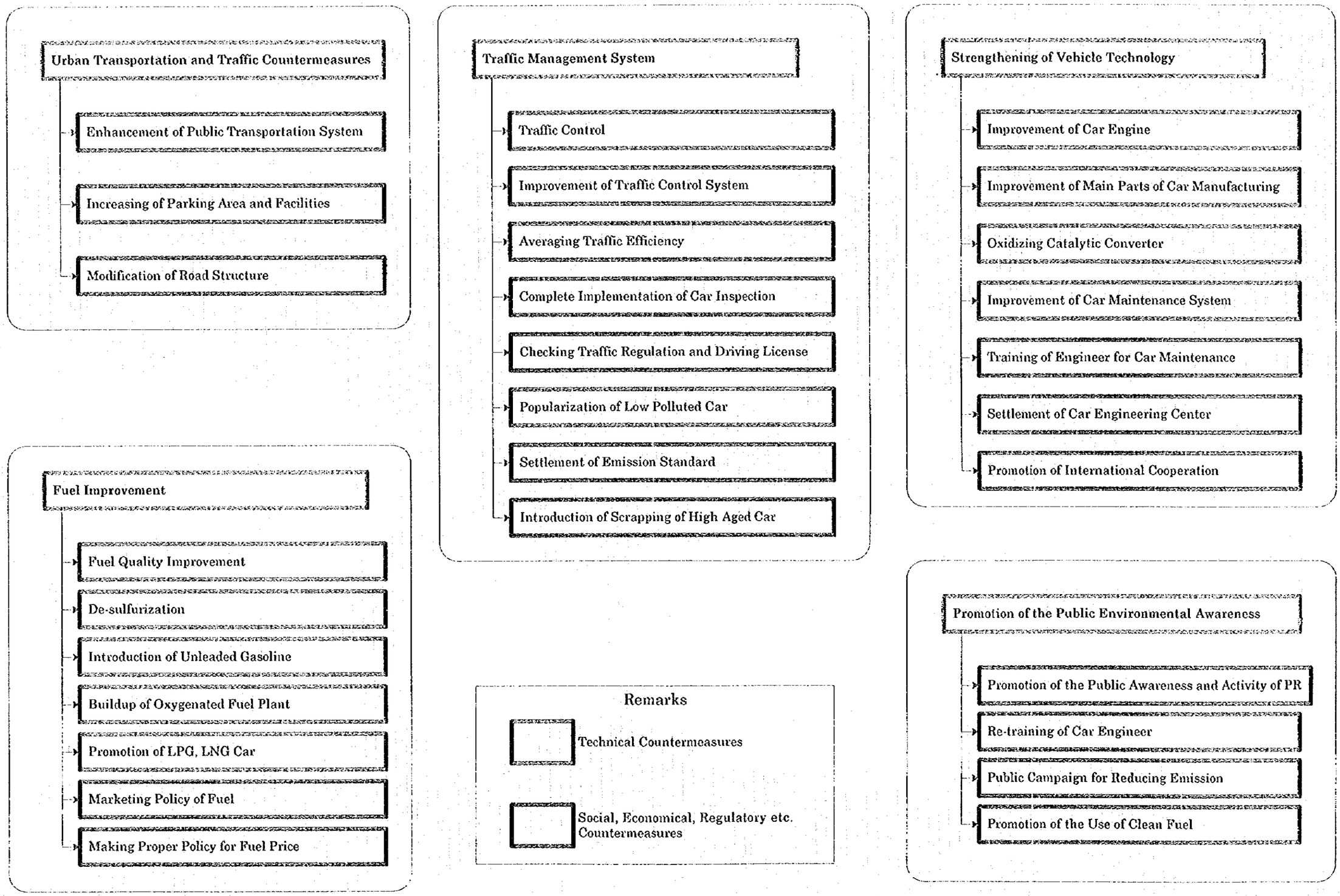


Fig. 6.2.1-2 Schematic proposals for improvement of automobiles, traffic system and social environment

6.2.2 Urban transportation and traffic countermeasures

(1) Enhancement of public transportation system

Districts 6,7,11 and 12 are the center parts of Tehran where government offices, business offices, buildings and markets are located. Citizens are commuting from mostly the suburbs to the center of the city districts are situated by means of different transportation. Almost all commuting vehicles are private cars, buses and taxis.

There are more private cars than the public transportation vehicles. As people park their cars on streets or behind buildings due to the shortage of parking spaces, road parking makes streets narrow, worsens traffic jams and prolongs traveling time.

Furthermore, such parking prohibits the city's economic activities, and causes air and traffic pollution with increasing noise and congestion. For avoiding such a condition, it is necessary to expand the public transportation system as a matter of the first priority. As we have seen many successful examples in other countries. We would like to consider how Tehran can improve its public transportation.

1) Guidance to the public transportation

In order to activate the public transportation system, MOT' needs convenient transportation facilities and services from the viewpoint of convenience of passengers. In the light of the situation of traffics in Tehran, the following countermeasures are recommended for MOT's consideration.

- Facilitating passengers' transfer to other means of transportation
- Centralization of management of the public transportation systems
- Establishing priority of public transportation system
- Appropriate investment for construction of public transportation systems

The means of public transportation in GTA are buses, mini buses, taxis, railroads, trolley busses, and subways which are now under construction. Using multiple means of transportation, a passenger usually rides several public carriers to transfer until one gets to the destination. Under such circumstances, enhancement of

park-and-rides, bus stops and parking facilities as well as time adjustments for transfer are needed so that users can transfer conveniently without cumbersome procedures. Because the public transportation mentioned above are run by different management, passengers must pay their fare each time when they transfer. In order to improve this managing system, MOT needs to unite the current administration and management so that opinions of different management will be harmonized and a way to distribute fare earnings will be decided.

The population of the inner Tehran area reached seven millions in 1994. In view of the traffic situation of Tehran, pursuing convenience and comfort by owning a car will significantly prevent the city from developing properly and functioning efficiently and, as a result, diminish the potential of the city. The availability and advancement of public transportation not only alleviates traffic jams and air pollution, but helps to save expenses for transports and thus increases the efficiency of energy consumption. In addition, it will help the whole country of Iran save natural resources and, as a result, prevent the Earth from becoming warm due to the greenhouse effect. The public transportation is an essential base of life for the aged, children and the disabled who have no means of transportation. In terms of the city planning of Tehran, development of public transportation is an important foothold that accelerates the advancement of the city.

From this point of view, it is clear that MOT needs to take the primary responsibility for improving the public transportation. In the next section, we will take up busses, mini buses, trolley buses, taxis and subways to set priority among the MOT's countermeasures.

In general, it costs a great deal to manage public transportation. There are two revenue sources: one is a self-supporting accounting system whose principal income is fare revenues, and the other is a system with combined income from fares and subsidy from the government and municipality. Developed countries tend to choose the latter to secure funds for promoting the public interests.

There are several other ways for securing funds for example, road pricing, parking fees and parking meters, penalty for violations of traffic regulations, fuel tax and fines against air pollution. In case of introducing the revenues should be used only for improvement and expansion of public transportation system. On the other hand, it is also important to make it known to everyone and to promote public awareness of their contribution to the air pollution control through using the public transportation system and raising funds supported by such tax and fine.

2) Activation of the UBC bus

The UBC bus (mini-bus) is taking an important part in the public transportation of Tehran, to which all kinds of constructions, improvements and innovation of laws are indispensable. As for activation of the UBC buses, we will suggest the following measures:

- Revision of price systems (Discount, Support system)
- Introduction and reinforcement of high speed buses (Shuttle bus)
- Enhancement of park-and-ride and bus terminals
- Optimal location of bus terminals and bus stops
- Priority of bus lanes
- Extension of bus lanes
- Introduction of information systems for bus location

Tehran is enforcing a restriction to keep private cars away from the center of the city by setting restricted areas and three park-and-rides (another facility is now under construction). Further, we propose to introduce a transit-first policy which limits car influx into the city by establishing "park-and-ride" and "bus terminals" at main points of trunk roads leading to the central city.

To encourage people to use buses, we recommend considering a discount ticket system and the "price revision" system to be initiated by the government and municipality such as a bounty system of carfare by the government and municipality.

Also, the priority bus lane and increase in bus lanes are to improve traveling speed. Further, it is desirable to choose the optimal location of bus terminals and bus stops. The information system for bus location would also be effective for improvement of passenger services and minimizing their waiting time.

For a discount ticket system, a reduce fare pass which the Tehran municipality used to issue temporality in the past, is considered desirable. A person with a pass should be ensured to transfer without additional cost.

Though there are bus lanes on most trunk roads, firmly establishing the priority of bus lanes is effective in the present situation. According to TCTTS and TTTO, since it is known that dedicated bus lanes or exclusive bus lanes shorten traveling time, needs for law amendment to ensure the preferential status of a bus should be appealed. Enforcement by the traffic police and the publicity through mass media needs to be stepped up.

As trunk roads in Tehran are wide enough to have more than three lanes, it is easy to construct exclusive bus lanes. MOT's immediate policy step should encourage citizens to take buses by extending bus lanes.

We also propose provision of better services to bus users. Because of the increase in automobiles and traffic jams, buses cannot run on schedule. The improvement of bus stops and making the interior comfortable would help improve bus services.

Through the plan of the bus network and bus stops is under the responsibility of UBC or TTTO, the entire bus schedule covering six districts should be reconsidered in accordance with the prospective locations of shopping malls or housing compounds being developed by the city of Tehran. For this purpose, more research is needed based on the person trips survey and OD research on bus passengers.

3) Expansion and activation of trolley bus

Trolley buses are now in operation in the eastern part of Tehran and transport

62,000 passengers per day (1995). They are more effective means of mass-transit than a UBC bus, causing less air pollution. At present, Line 3 is under construction and planned to run from the south to north. In the long run it is expected to run through the whole city.

It would be desirable to construct a trolley bus lane when dedicated bus lanes are defined, so that construction expenses will be saved by converting a bus lane into a trolley bus route. To extend trolley bus lanes throughout the city, they should be planned in consistency with the street-widening and other improvement projects which are being implemented. The trolley bus extension project has several difficulties including structural problems about median strips, laying of overhead wires, and raising construction funds. However, Light Rail Transit (LRT), a variation of a trolley bus, in big cities in Europe plays an important role in decreasing private cars and is successful as a means of public transportation.

The measures for promotion of the trolley bus is similar to that of the UBC bus; it is particularly important to consider the park-and-ride system and the link to the main parking lot, and the trolley bus fare should not be very different from UBC bus fares. Desirably people should be allowed to transfer freely between a UBC bus and a trolley bus with a pass.

Although a trolley bus was planned to go out of service on the grounds that it blocked other automobiles for a time in the past, it is now regarded as an important system indispensable to modern cities. We believe that the trolley bus will help improve the image of Tehran if it is closely linked to the UBC bus.

4) Improvement of taxi system

There are three kinds of taxis in Tehran: about 25,000 painted taxis, which belong to the Taxi Organization, agent taxis registered as a company system, and owner-driver taxis. The taxi belonging to the Taxi Organization is obligated to maintain the car. They are assigned their business territory. Recently a policy has been

implemented to encourage switching vehicle fuel from gasoline to LPG. On the other hand, agent taxis and private cars enjoy more freedom than colored taxis as to vehicle maintenance and territory.

Because the taxi plays an important role in transportation in Tehran, policies reducing air pollution addressing taxis have to be planned in a way different from policies addressing other pollution sources.

The share of taxis is 20 % of the entire automobile transports, transporting 3 to 3.5 million people a day.(Taxi Organization, 1995) In making a policy against traffic pollution, needs of such a great number of passengers should be taken into account.

A taxi driver of the Taxi Organization, for the time being is allowed to continue to work if they renew their licenses at their expiration. In the future, however, they will be required to take some steps for decreasing air pollution as we will be discussed in a later chapter.

In the meantime, the Taxi Organization should obligate all the agent and private taxis to register the vehicles and maintain them in proper conditions, and facilitate them to use LPG as fuel. Besides, though these taxies do not have their business routes specified, their business territories should be designated from the viewpoint of convenience of passengers transferring to other taxis belonging the Taxi Organization. As these taxis are used by several passengers jointly, they are expected to play a unique role from the viewpoints of efficiency and convenience, partially resembling a car pool.

5) Tehran subway system

The Tehran subway is now under construction or planning, consisting of the East-West Line, the South-North Line, the Tehran-Kraj Line and the Loop Line which will circle the city of Tehran. The subway has greater transit potential than any other means of public transportation, and reduces traveling time. According to the statement of the Tehran municipality, 1.5 to 3 million people are expected to shift to the subway from their present means of transportation when the subway starts. The subway

therefore will greatly reduce traffic congestion in Tehran. How to encourage people to use the subway will be an issue which will be discussed in "6.2.2.(1)-1. Inducement to encourage people to use the public transportation".

(2) Expansion and modification of parking facilities

Tehran has big park-and-rides and terminals at three places between the suburbs and center of the city where people can change their mode of transportation. In addition, there are many public parking facilities in the city, including more than 250 parking lots which hold over 20,000 vehicles. About 2 % of all the vehicles in the city secure their parking places in these parking lots. Some vehicles, however, are parked on the trunk roads and occupy a lane, and others are parked behind streets.

An elaborately designed city tends to limit construction of parking facilities on account of desirable utilization of the land. In Tehran's case, however, plans for the improvement and expansion of parking facilities are inevitable in order to alleviate traffic jams caused by decreased road areas on certain conditions.

For the purpose of improvement and expansion of parking facilities, the following four proposal are made:

■Increasing parking areas and facilities

In constructing parking facilities, there are some restrictions concerning capacity and construction expenditures according to the traffic volume of surrounding roads and policy of land use. Therefore in expanding city parking facilities, it is necessary that open spaces should be used within the limitations established by the MOT's land use plan. It is also proposed that multi-story parking garages be built and that parking facilities be placed underground of roads and parks. Furthermore, when new government buildings, office buildings, hotels and residential buildings are constructed, they should be furnished with parking facilities. Installation of an

announcement board on nearby roads for indicating location and availability of parking facilities is also effective.

■Introduction of parking meters

The introduction of parking meters, parking tickets, dial clocks, park locks and so on is proposed for parking for a relatively short period on open spaces or roads where traffic is not heavy, although it is not practical on trunk roads where traffic is heavy. The hours when these parking facilities are open should be carefully set according to the traffic condition on the roads.

■Obligation for government and private office building to have parking spaces

(Obligation for car owners to have parking spaces)

In Japan it is mandatory for every car owner to have a parking space regardless of whether the car is for public or private use (this system is called "garage certification"). The police enforces this system and a parking space certificate is necessary for the purchase of a vehicle.

This system reflects Japan's particular situation of very limited road spaces. Although the system is rare in the world, it has been successful (The certifications totaled 10,710,000 in 1994). Such a system may be worth considering in Iran.

■Reducing private car commuting

Reducing private car commuting is another measure to be considered. In addition to this, if the use of public transportation is promoted, much money is saved by dispensing with construction of additional parking facilities. To drive company cars back to workers' homes simply because their work place have no space for parking contradicts the idea of active utilization of public transportation.

Aside from the above-mentioned measures, it is proposed that violations of parking regulations should be tightly overseen in the following manners:

_ Installation of TV cameras in districts where traffic jams are caused by illegal

parking as well as warning with loudspeakers.

- Control of illegal parking should focus where on no-parking zones, intersections of trunk roads, crosswalks, bus stops and so on violations are most dangerous and troublesome. Violators should be arrested or their cars should be towed away.

(3) Modification of road structure

Concentration of the vehicle fleets in a particular area or road causes traffic jams in urban districts. Vehicles especially concentrate in intersections and merge areas, where bottlenecks tend to occur and the incidences of traffic jams and traffic accidents are most frequent. TTTO and TTCC have proposed elaborate plans to MOT and many efforts, including the improvement of intersections and the installation of traffic signals, are being made.

Moreover, it is suggested that countermeasures including adjustment of traffic signals to traffic conditions, introduction of left-turn lanes, and introduction of separated sidewalks by green belts be taken into consideration for the purpose of smoother traffic flow on roads and at intersections.

6.2.3 Traffic management system

(1) Traffic control

Even if devices for vehicle control and roads management are introduced and improvement of intersections and traffic signals is made for the purpose of smoother traffic, their effectiveness would be limited, unless vehicle traffic demand should be reduced. In this section, the following measures for reduction of vehicle traffic volume are explained.

■ Expansion of restricted areas in the CBD(Central Business District)

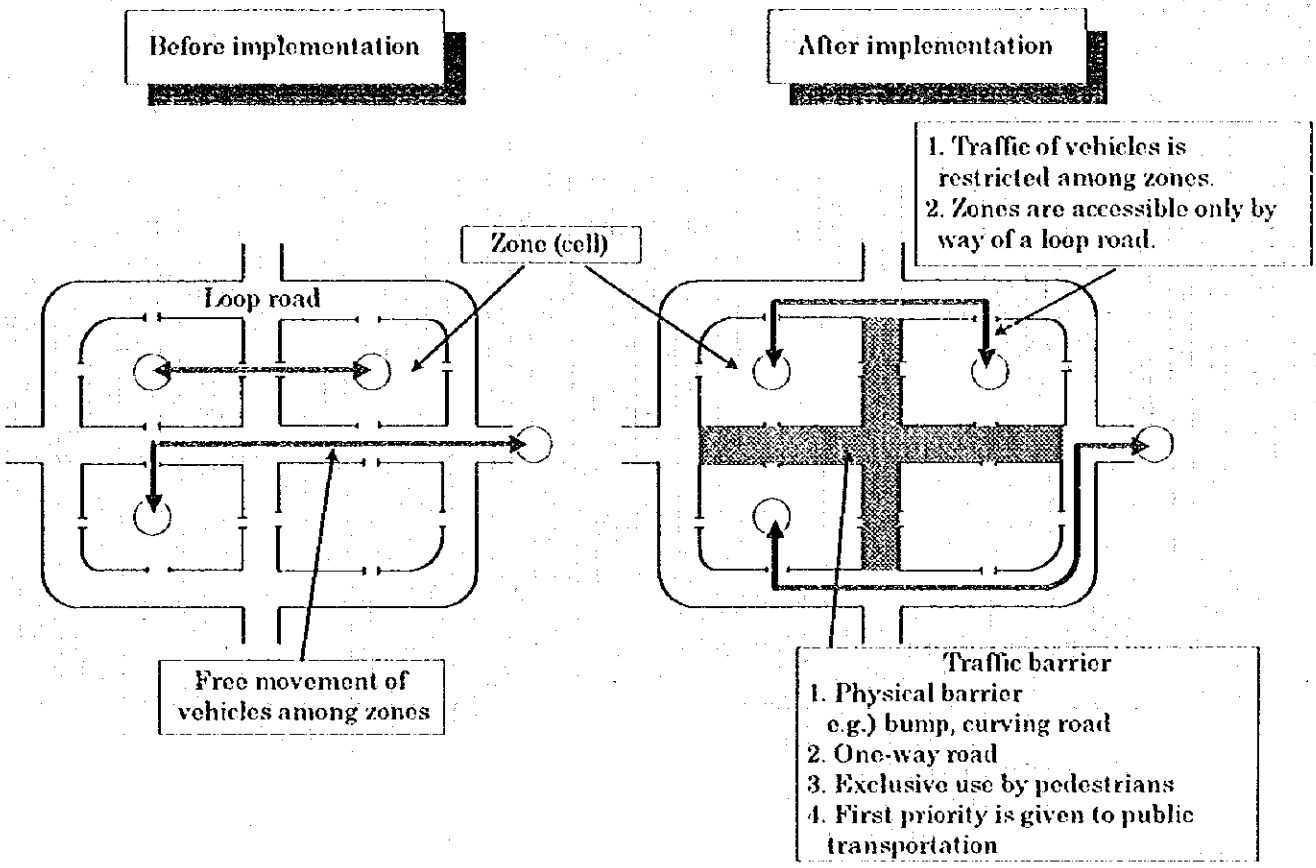
■ Introduction of an additional restricted area during rush hours

Restrictions on vehicles entering the restricted area as well as particular roads in all day or during limited hours are popular in many countries as countermeasures against vehicular traffic increase. MOT takes similar countermeasures, specifying an area in the center of business districts where the entrance of passenger vehicles is restricted from 6 a.m. to 5 p.m. on working days (from Saturday to Wednesday). MOT intends to extend the restricted area in the northern or eastern district. It is recommended to give priority or a car-driving privilege to downtown residents and workers of local companies in the center part of the city.

■ Traffic zone system

The idea of the system is to divide the center of the city into several traffic zones to make each area accessible only via a loop road which surrounds the center part and to traffics between the zones. This system has been adopted in many European countries and has been successful. Boundaries between zones have only a slight difference in height, so that ambulances and patrol cars as well as buses and trolley buses can cross them.

In applying this system to Tehran, further consideration should be given to what trunk road should be specified as loop roads in compliance with plans for the UBC bus and trolley bus routes. The feature of the proposed traffic zone system is as follows.



■Introduction of road pricing system and area license system

The road pricing system is a measure designed to alleviate traffic jams by charging tolls on drivers who drive downtown or enter into the center part of the city. Through the system, revenues will be gained and can be spent on improving public transportation facilities, roads and so on.

In implementing the toll system, a reliable method of avoiding traffic jams at the toll gates should be worked out, as well as controlling misdemeanors such as passing through without paying the toll. A prepaid card system is effective for these objectives. According to the statistics of many countries that introduced the system, traffics volume in the downtown area has decreased 5 to 10 %.

■Establishing a traffic control area

(Alteration of lane widths and creation of bumps)

This measure aims to improve conditions in residential areas as well as in the center of the city. Vehicle speed is to be lowered by speed bumps on roads or by twisting and curving roads in target areas. The entrance speed of vehicles should also be controlled by narrowing lanes at the entrances of target areas. Although vehicles are permitted to enter these areas, speed is kept at a minimum within the areas as drivers must restrain their driving because of presence of speed bumps and twisting roads. Consequently, vehicular entrance to these areas is discouraged, while bicycle riders and pedestrians are little affected and move safely in the areas.

(2) Improvement of the traffic control system

MOT has a traffic control center in TTCC which provides citizens with traffic information and also provides the police officers with the information necessary for their controlling activities. The followings are the measures to be taken to achieve a high-quality system are shown below.

■Improvement and optimization of the traffic signal system
■Controlling signals on weekdays and during particular hours of the day
■Introduction of optical sensors

Traffic signals can be controlled by using existing traffic counters and AADT vehicle sensors. During rush hours, however, the timing of traffic signals should be adjusted manually by police officers who may control traffics directly. In order to control traffic efficiently in areas with many intersections and squares, the measures stated below should be taken. It is estimated that, if a proper condition is met, about 5% of pollutants will be decreased.

- To change the controlling methods from spot control to a route control or area control method.
- To prepare several patterns of signal timing according to the day and hour.
- To automate the selection of these controlling patterns according to the traffic conditions based on the information gained with vehicle sensors installed at

merging points or at intersections.

Improvement of the sensors measuring traffic volume and traffic counters including by use of supersonic and optical sensors is indispensable to better control of a signaling system. It is necessary to analyze the information obtained from these sensors and make a database of signal controlling patterns in order to apply the most suitable pattern in accordance with the traffic conditions.

Aside from the above-mentioned methods to be used to control individual signals, computerized total control of the system is becoming a notable new method for controlling traffics and has been successful in many countries.

■Monitoring traffic conditions with a remote control camera

■Controlling vehicles speed and parking (in cooperation with the police)

TV monitors have been installed at more than 50 main intersections in the city, where traffic conditions can now be observed on screens in the TTCC traffic control center.

The centers main task is to provide citizens with traffic information via radio and also provide MOT-related organizations and police officers with current information. By means of the above-mentioned monitoring device, the following warnings may be issued via loudspeakers:

_ Warnings to drivers who do not enter intersections safely.

_ Warnings to drivers who cut in a lane or zigzags.

_ Warnings to passenger car drivers who use bus lanes.

_ Requests to drivers to slow down near intersections.

_ Warnings against illegal parking.

■Establishment of traffic condition information system and so on.

It is indispensable to provide drivers with information about traffic regulations in order to secure safe, smooth and comfortable traffic conditions. Typical methods of communication, in addition to radio broadcasts, use road signs as described below:

Type of information	Contents
Road guide	Routs guides, place names, structure of roads, distance and time required to the destination, fare etc.
Road side information	Parking guide, the sights, event guide etc.
Traffic information	Traffic jams, traffic accidents etc.
Regulations	Restricted areas, restricted lanes, one-way streets, speed limits,
Road information	Road surface conditions, no thoroughfare, falling stones
Weather information	Rain, snow, wind, fog etc.
Others	Warnings (slippery roads, crosswinds) Vacancies of parking spaces

The TTCC Radio Payam Broadcasting has been authorized by the city and worked satisfactorily. Traffic signs, on the other hand, are in short supply and some of them are broken or not clearly drawn. The improvement of traffic signs is necessary. For improvement of traffic signs, the installment of larger-size signs and introduction of overhead and overhang signs are desired, as well as improvement of the existing inspection system of traffic signs. In addition, improvement of the device for providing information is indispensable, including more use of various displays that adjust signs to the changes in regulations corresponding to the hour.

If proper measures are taken, such as the above-mentioned traffic control system, reflecting timely traffic information, it becomes possible to prevent traffic bottlenecking by distributing and guiding vehicles properly, leading to smooth and comfortable traffic flows.

(3) Distribution of traffic and improvement of traffic efficiency

The followings show several measures designed to improve vehicles' performance and reduce incidences of traffic jams and air pollution by devising effective ways to use vehicles and by evenly distributing traffic which tends to concentrate during particular hours and on particular areas.

■Prohibition of left turns

■Establishment of separation zones (prohibition of U-turns)

■Reverse lanes

The above-mentioned measures are for the achievement of smooth traffic flow using existing traffic facilities in such a way that effectiveness will justify its cost.

Vehicles turning left and making U-turns despite heavy traffic greatly impede traffic flows. Therefore if a road is not wide enough or other proper measures such as improving signals for the left turn or specifying left turn lanes are infeasible, left turns and U-turns should be prohibited.

A reverse lane system may be applied to the roads where traffic is concentrated in one direction during particular hours as in the case of Tehran's trunk roads. Further discussion is needed whether the center lane displacement method or the reverse / one-way lane method should be chosen. If bus lanes are also set up, roads can be used more effectively. Because many trunk roads in the city have the center zones which separate the lanes running in one direction from those in the other, careful consideration should be made whether or not the reverse-lane system should be used in the light of specific situations.

■Introduction of flextime

This system has been carried out in many countries and has been successful as an effective way to avoid traffic concentration during particular hours such as the morning and evening commuting hours. Varying commuting hours and the intensive

working system are most popular. Such systems are expected to play an important role in improving traffic conditions and are worth considering for application in MOT.

_ Varying commuting hours

This system allows workers to vary the time when they start or finish work so that a concentration of commuters can be avoided. In MOT, this system was implemented about five years ago, but was abandoned due to its strict procedure and the customs of dropping school children on the way to the work. Because the purpose of introducing flextime is to keep traffic flow constant, the improvement and utilization of public transportation is a necessary precondition. Therefore the reintroduction of the system should be discussed along with promotion of public transportation, in consideration of the past experience.

The national government and MOT should lead deliberation of the system and carry out the public relations activities to encourage companies and the general public to adopt the system.

_ Intensive working system

This system allows workers to work for many hours on particular days and less hours on other days, provided that the agreed total number of hours are spent at work each week, leading to reduced working days and consequently reduced traffic jams.

■Sharing system

■Enhancement of a commuter bus

Car pools and van pools are effective methods in which several commuters share a ride to reduce use of commuter vehicles. The countries that adopt and promote this system offer the privileged parking and fare rights to poolers.

Though the system works well with taxis in Tehran, only a small number of buses are chartered by the government organizations and big companies. The system should also be propagated by the national government and MOT through public relations activities which encourage companies and the general public to use the system.

(4) Improvement and strengthening of car inspection

Air Pollution Control Act (1995) states that all passenger cars which access to the traffic-restricted area are obligated to have maintenance and inspection every 12 months, and also in case of changing of ownership, the car has to be inspected. It is said, however, that only 25 to 40 % of drivers actually comply with this duty. The statistics indicates a great threat to vehicle safety as well as an impediment in the quest to reduce air pollution. As regular inspection and maintenance of vehicles is the duty of their owners, some proposals to encourage compliance are stated below:

■Complete implementation of car inspection with penalties

No penalty is currently imposed on owners who fail to bring in their vehicles for maintenance and inspection except for 10,000 rials fines imposed by the police. Police control is not very strict and thus many owners neglect their duty.

In order to ensure the complete compliance, it is indispensable to establish organizations in charge of registration of vehicles so that the national government and MOT can know the total number of vehicles. In addition, laws need to be made obligating vehicles purchasers to register their vehicles when purchasing regardless of whether it is a new or used car and to buy obligatory car insurance such as vehicle compensation insurance.

A database should be made by collecting the registration data. After the database is made, the next steps may be as follows:

Reports concerning vehicle compensation insurance need to be sent to vehicle owners every year as well as the notice for regular vehicle inspection and maintenance. Owners should have their cars inspected and maintained and present to MOT the certification which proves that the cars have been through inspection and maintenance. Should owners neglect this duty, they should be deprived of their driver's licenses.

The cost for regular inspection and maintenance in Tehran is 3,000 rials per vehicle (fixed) plus 1,000 rials for each cylinder (varied), with additional charges for spare parts.

If any appropriate charging system is introduced providing proper privileges to certain groups of people, the inspection and maintenance will be promoted.

■Improvement of inspection facilities and man-power development

These are currently 90 inspection and maintenance workshops for automobiles and 80 for motorcycles in the city, which are not enough to carry out inspection and maintenance of all vehicles. As MOT is planning, at least two times as many as the current facilities should be constructed as soon as possible. Moreover, each workshop should be staffed by qualified engineers who have special knowledge in vehicle engineering and are able to maintain a high level of technology in the inspection and maintenance of vehicles. At the same time, the emission standards and emission controls specified by the national government and MOT should be observed through the inspection and maintenance.

■Car inspection check-items

The targets of inspection and maintenance are body, painting, wipers, mirrors, bumpers, clutch, gears and so on according to the items of the TVTIB's inspection and the inspection center's check-list. The inspection is carried out by mainly looking at the external appearance and therefore the time taken for the inspection procedure is very short. In consideration of needs for the reduction of air pollution and the safety of the vehicles, detailed inspection of at least the following items is necessary:

System	Check items
Power system	engine, oil, fuel system, radiator
Steering	wheel alignment, power steering system
Brake	pedals, hand break, hose and pipe, brake drum, brake shoe, brake disc
Power transmission gear	clutch, transmission, shaft
Electrical system	headlight, horn, electric windshield wipers, defroster, battery
Buffer system	chassis spring, suspension
Tire	air pressure, tread
Smoke and harmful gas protectors	boost control valve(for blowby gas), fuel evaporation protector, oxidation catalyst

As an illustration of items for inspection and maintenance, the items to be checked in regard to private cars for every 6, 12 and 24 months in Japan are listed in Table 6.2.3-1~2 respectively (the term maintenance is distinguished from the term inspection: the former is carried out every 6 and 12 months, while the latter every 24 months). Figure 6.2.3-1 shows the sequence of the inspection process.

■Creation of a car database for policy planning

MOT is planning to introduce vehicle emission density regulations in the city, which are to be led by TVTIB and AQCC. A database should be made based on the information collected when cars are inspected so that a proper density value can be specified.

Table 6.2.3-1 The inspection and maintenance standards for passenger car

Check point and item / Inspection intervals		6 months	12 months (include 6 months items)	24 months (include 12 months items)
Power system	Engine	1.Condition of acceleration and idling 2.Exhaust gas of CO, HC and PM on idle state	1.Condition of engine start and unusual noise 2.Condition of acceleration, idling, engine stop and knocking 3.Condition of exhaust gas 4.Condition of air cleaner element	Valve gap by thickness gage
	Oil	Dirt of oil and quantity	Oil leak	
	Fuel system		Fuel leakage	1.Link condition of carburetor attachment 2 condition of throttle valve and choke valve 3.Fuel injection pressure and injection condition of nozzle 4.Fuel injection timing and injection quantity
	Radiator	1.Liquid quantity 2 Looseness and damages of fan	Liquid leakage	Dirt and damages of radiator cap and radiator valve seat
Steering system	Handle		1.Play and looseness 2.Checking the condition of operation	
	Gearbox			1.Oil leak 2.Looseness of the attachment
	Rod and arm		1 play, looseness and damages 2.Cracking and damages of the dust boot(sealing boot) of ball joint	
	Knuckle			Checking the condition of connection
	Wheel alignment			1.Wheel alignment camber, caster by tester 2.Revolution angle of the right and
	Power steering	Looseness and damages of belt	Oil leak and oil quantity	Looseness of the attachment
Brake system	Brake pedal	1.Play and gap with floor board 2.Working condition of brake		
	Hand brake	Connections reign	Working condition of brake	
	Rod and arm			Play, looseness and damages
	Hose and pipe	Oil leak, damages and attachment condition		
	Reservoir tank	Liquid quantity		
	Master cylinder Wheel cylinder Disc caliper		Wheel cylinder and the liquid leakage of disc caliper	Working condition, abrasion and damages
	Brake booster			Working condition
	Brake drum, brake shoe		1.Gaps of drum and lining 2.Abrasion of brake shoe and lining	Abrasion and damages of drum
	Brake disc, brake pad		1.Gaps of disc and pad	Abrasion and daniages of disc
Power transmission gear	Clutch	Play and gap from floor board	1.Working condition 2.Liquid quantity	
	Transmission		Oil leak and oil quantity	1.Looseness and damage of attachment 2.Deterioration of attachment
	Propel shaft and drive-shaft		1.Looseness and damage of attachment 2.Cracking and damages of universal joint and dust boot	1.Deterioration of attachment 2.Deterioration of center universal joint 3.Deterioration of center bearing
	Differential gear		Oil leak and oil quantity	
Electric system	Ignition	1.Condition of ignition plug 2.Ignition timing	1.Condition of ignition plug 2.Ignition timing 3.Condition of relay 4.Condition of distributor cap 5.Performance of advancer(retard)	
	Battery	Liquid quantity	1.Specific gravity 2.Connection condition of terminals	
	Electric wiring			Looseness and damage of attachment
	Headlight Turn signal indicator	Working and performance		
	Horn Windshield wipers Defroster		Working and performance	

Table 6.2.3-2 The inspection and maintenance standards for passenger car

Check point and item \ Inspection intervals		6 months	12 months (include 6 months items)	24 months (include 12 months items)
Buffer system	chassis spring			Damages
	Attachment and connecting part			1.Looseness and damage of attachment 2.Deterioration of attachment
	Suspension arm			Deterioration of attachment and damages of arm
	Shock absorber			1.Oil leak and damages 2.Deterioration of attachment
Tire	Wheel	1.Air pressure 2.Cracking and damages of tire 3.Depth and abnormal abrasion of the tread 4.Metal fragments, stones, others	Looseness of wheel nut and wheel bolt	1.Dameges of rim and wheel disc 2.Deterioration on front wheel 3.Deterioration on rear wheel
Smoke and harmful gas protectors	Boost control valve for blowby gas			1.Condition of meter ring valve 2.Damege of hose and pipe
	Fuel evaporation protector			1.Damege of hose and pipe 2.Clogging and damages of charcoal canister 3.Performance of check valve
	Oxidation catalyst 3 way catalyst		1.Looseness and damages of catalyzer attachment 2.Performance of secondary air supply system 3.Performance of exhaust gas recirculation system 4.Exhaust gas reduction device on deceleration state 5.Dameges of hose and pipe	
	Heat protector		Looseness and damages of heat insulator attachment	
Others	Indicating meter for car driving[	Working and performance		
	Exhaust pipe and muffler		Looseness and damages of attachment	
	Car body and car frame			1.Door lock 2.Looseness and damages
	Seat			Condition of seat belt
	Lubricating oil		Condition of lubricating oil for chassis every part	

Data Source: Ministry of Transport(Japan), The Law of road, transport and vehicle(Article 43)
Vehicle technology handbook, 1992, Society of Automotive Engineers of Japan(JSAE)

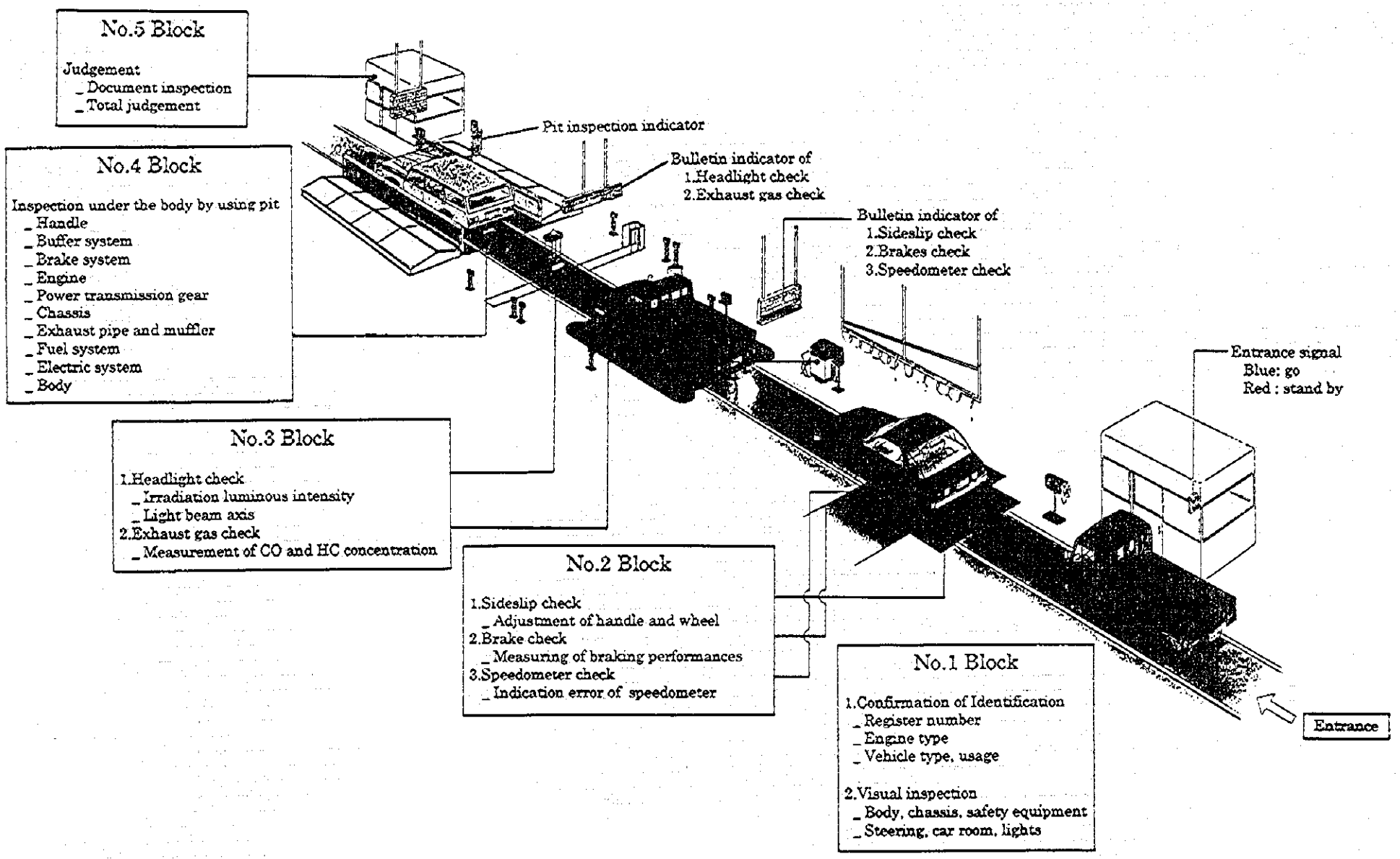


Fig.6.2.3-1 The configuration of inspection equipment and main inspection item

(5) Checking traffic regulations and driver's licenses

Drivers and vehicle owners are obligated to observe vehicle transport regulations, drive safely and have a driver's license. As violators of safe driving and traffic regulations are supposed to receive tough penalties, the policy is regarded appropriate in its concept. The implementation of this policy, however, reportedly lenient.

In order to reduce not only vibrations but also vehicular air and noise pollution, as well as to ensure the safety of pedestrians, existing regulations need to be reviewed and stricter police control be made.

■Strengthening of traffic regulations

Vehicle transport regulations should be strengthened to ensure smooth traffic conditions by making drivers thoroughly observe existing traffic regulations such as speed limits, no parking zones, no passing, no driving out of lanes on the left, no U-turns and so on. In addition, a priority should be given to public transportation means.

As for the safe driving, measures for prevention of traffic accidents should give priority to protection of pedestrians and bicycle riders. Residents, especially elderly people, children and facility users should be protected, through designating residential areas, school zones, hospitals and supermarkets as safe areas. Noise pollution and vibrations should also be reduced.

As for vehicle owners duties, regular inspection and maintenance are indispensable as a measure to reduce air pollution. In addition, whether or not owners have a proper place to park their vehicles should be strictly checked with a view to eliminating the illegally parked vehicles which create interference on the roads.

The above-mentioned concept is reflected in current Iranian laws. Prompt action which promises practical results is urgently needed.

■Establishment and improvement of driver's license system

In connection with drivers licenses, driving schools should improve lectures in driving techniques, vehicles and traffic regulations. A curriculum should be introduced focusing on reduction of air pollution as well as on the necessity of regular inspection and maintenance, securing parking places for vehicles, and giving priority to public transportation.

When driver's licenses are renewed or reissued, applicants should be obligated to take a training course on the importance of air pollution reduction and safe driving.

The following is an example of a way to improve the driver's license system. Figure 6.2.3-2 shows how a passenger car driver's license is obtained in Japan.

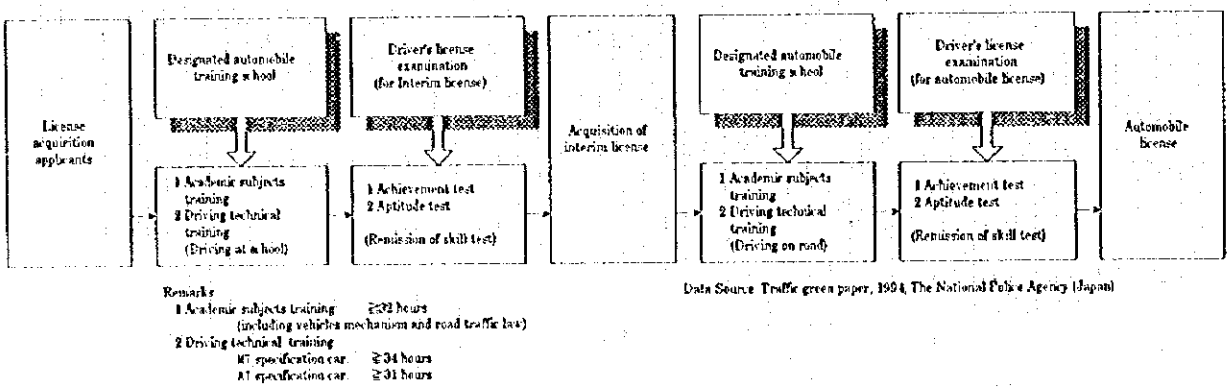


Fig.6.2.3-2 System for acquiring passenger car driver's license in Japan

The applicants seeking to obtain a driver's license in Japan are obligated to take more than 32 hours of study courses and more than 31 hours of technical training courses (The number of hours varies according to the kind of license desired or more hours are required for applicants who failed in qualifying examinations. The above-mentioned hours are the minimum required). Moreover, an applicant is supposed to obtain an interim license, followed by technical training for driving on roads as well as a written examination before the license is acquired.

The study course includes the following subjects:

- Road traffic laws
- Vehicular maintenance
- Methods of predicting danger and safe driving
- Methods of avoiding and dealing with traffic accidents as well as first-aid
- Driving etiquette

In addition to methods of avoiding and dealing with traffic accidents, which are the principal subjects in the study course offered in Japan, the following countermeasures against vehicular pollution may be included as main subject in Tehran:

- Thorough vehicular inspection and maintenance
- Obligation to have a garage
- Current situation of vehicular pollution and countermeasures to deal with the problem

If possible, the following subjects should be included in the technical driving training course:

- Giving priority to public transportation
- Giving priority to pedestrians

It would also be effective to adopt a license renewal system in which licenses are effective for three to five years. When a driver's license is to be renewed, an applicant should be obligated to take a training course on countermeasures against pollution as well as an aptitude test for driving.

(6) Popularizing low-pollution cars

For the purpose of reducing vehicle emissions, the promotion of low-emission cars, as well as an introduction of emission regulations is crucial.

As for low-pollution cars, electric cars, natural gas cars, methanol cars and hybrid cars are being developed, whose features are as follows:

Types	Power source	Advantages	To be improved
Electric car	_ Uses motor via an electrically _ Charged battery as power source	_ Free of emission _ Small noise	_ Expensive _ Needs battery equipment _ Only short trips possible _ Low acceleration performance _ Heavy in weight
Natural gas	_ Uses compressed natural gas for fuel	_ Natural gas is abundant in Iran _ Free of PM emission _ Nox emission is controllable with combustion technology and catalyst	_ Needs filling equipment _ Heavy in weight with high pressure gas container _ Safety measures need to be taken for high pressure gas
Methanol car	_ Uses methanol for fuel	_ Methanol synthesizing technology from natural gas is available _ Free of PM emissionsame amount of Nox emission as that from gasoline car	_ Fuel-inefficient _ Durability of spark plugs and catalyst _ Incomplete combustion of HCHO and methanol
Hybrid car	_ Energy produced when brake is on converted electricity and charged. When starts,usual engine and motor are simultaneously used.	_ 20 - 30 % less emission compared to diesel car	_ Heavy in weight with battery and motor

Even in the countries which are advanced in technology for low-pollution vehicles, these cars are still not practically used. The current ideas of developed countries for popularizing low-pollution cars are as follows:

- Guidance for using low-pollution cars
- Subsidies for using low-pollution cars
- Subsidies for buying low-pollution cars

Iran is the world's largest producer of natural gas. LPG-fueled vehicles are used mainly for taxis in Tehran and the filling stations are ready to meet demands for LPG. In view of these current conditions, it seems most appropriate to encourage use of LPG-fueled vehicles.

The mass production system has not yet been established for low-pollution cars. For this reason, the price of these vehicles is higher than existing cars. Therefore it is indispensable to introduce some support systems such as subsidies or tax allowances for them. The countries which are trying to promote low-pollution cars provide various subsidies listed below:

- Supporting system for the introduction of low-pollution cars
  - Subsidies for promotional activities introducing low-pollution cars
  - Subsidies for the expenditure necessary to remake existing vehicles into low-pollution cars
  - Leasing of electric cars
  - Subsidies for promotional activities introducing LPG-fueled vehicles
  - Subsidies for promotional activities introducing low-pollution trucks
  - Subsidies for popularizing "eco-stations"
    (An eco-station supplies automobile fuels including gas fuel and gasoline as well as batteries and other things, automobile fuel addition to gasoline.)

- Tax allowances for low-pollution cars
  - Reduction of income tax and corporate income tax
  - Reduction of the vehicle purchasing tax rate for business and private use
  - Deferred tax payments
  - Privileges for natural gas and methanol filling facilities

Moreover, for the purpose of popularizing low-pollution cars, the improvement of the filling stations supplying low-pollution fuel is important as well as improvement in vehicle performance and cost-cutting through technology development. An effective way to improve the fuel supply infrastructures is to combine regular gas stations and LPG stations with energy stations for low-pollution cars.

■ Encouraging use of low-pollution cars for official use

To achieve the further utilization of low-pollution cars, introduction and adoption of these cars by public organizations are desired. For example, these cars can be used for garbage collection or pollution patrol. When government-owned vehicles now in use are replaced with new cars, purchase of low-pollution vehicles should be considered in consideration of running distance, carrying capacity and geographical conditions.

It is also important to carry out public relations activities encouraging prevention of air pollution.

(7) Establishing emission standards

MOT plans to introduce the emission standards to be established by DOE pursuant to the Clean Air Act. For the standard for new cars, MOI is planning to apply the ECE 15.04 mode to new cars produced locally.

Emissions of CO, HC, O_2 and CO_2 during engine idling are controlled for in-use cars with a concentration measurement tester at car maintenance workshops as a tentative measure until the emission regulations are put into effect.

Because setting the emission standards is beyond the capability of MOT, wide-ranging discussions including a long-term goal and legislation procedures should be carried out by national governmental organizations such as DOE, MOI and MOO.

Aside from the above-mentioned CO and HC emissions, the emissions of PM, lead, sulfur and harmful gases should also be controlled.

In view of the current condition of air pollution in Tehran, emission regulations are urgently needed. In developed countries implementing various measures to cope with air pollution, the enforcement of emission regulations has been successful. In addition, the emission standards are expected to provide an opportunity to develop combustion technology of vehicular engines, to improve fuel quality and to promote low-pollution cars.

MOT needs to know the current conditions of vehicle emissions in the city in order to specify the emission standards. TVTIB and AQCC are making efforts to collect the information in GTA. Unless the standard should be based on these data, the regulations would not be observed.

Driving tests and C/D tests for each type of vehicles have been carried out through the field survey. Making the most use of these results, MOT should introduce the regulations using a measuring mode while the authorities should also pay attention to the current conditions of emission controls in other countries.

The emission standards should set their target according to each vehicle's type and age, and should be implemented through several stages.

With the shifting from the density regulations which have now been put into effect to emission controls, engine improvements and specifications of supplementary parts are required meeting the emission control regulations as well as securing better fuels. Emission regulations are usually enforced step by step according to the state of air pollution supported by the technological improvement of vehicles. In order to reinforce emission controls, both government and private bodies in developed countries have worked together to achieve better vehicular technology and been engaged in research and development for the past 20 to 30 years. Vehicle manufacturers have been obligated to produce vehicles which meet emission regulations. Existing vehicles are not allowed to be used, although owners of these vehicles have been given some time before they are subjected to the rule.

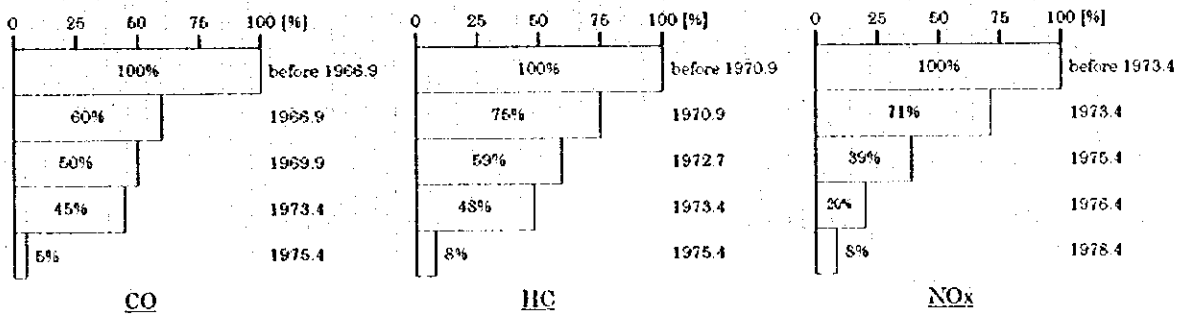
Here in Iran, when a new emission regulation is introduced, considerable time and cost for study will be required for dealing with the regulation. It is hoped, however, that the time and cost for research and development will be saved by introducing vehicular technology from developed countries. Table 6.2.3-3 and Figure 6.2.3-3 show the history of Japan's emission regulations on CO, HC and NOx levels, as well as the records of automobile emission reduction in Japan.

Table 6.2.3-3 Japan's emission regulations for automobile

Object \ Regulation year		1973	1974	1975	1976	1977	1978	-----	1997
CO	Max.	26.0	←-	2.70	←-	←-	←-	-----	←-
[g/km]	Ave.	18.4	←-	2.10	←-	←-	←-	-----	←-
HC	Max.	3.80	←-	0.39	←-	←-	←-	-----	←-
[g/km]	Ave.	2.91	←-	0.25	←-	←-	←-	-----	←-
NOx	Max.	3.00	←-	1.60	0.81	←-	0.48	-----	←-
[g/km]	Ave.	2.18	←-	1.20	0.60	←-	0.25	-----	←-

Data Source: The countermeasures for automobile environment, 1996, Environmet Agency(Japan)

Remarks : This emission regulation is for a passenfer car (4 cycle gasoline engine)



Data Source: The countermeasures for automobile environment, 1996, Environmet Agency(Japan)

Remarks : This emission regulation is for a passenfer car (4 cycle gasoline engine)

Fig. 6.2.3-3 The anticipated reduction effect of automobile emission in Japan

(8) Scrapping high-aged and low performance cars

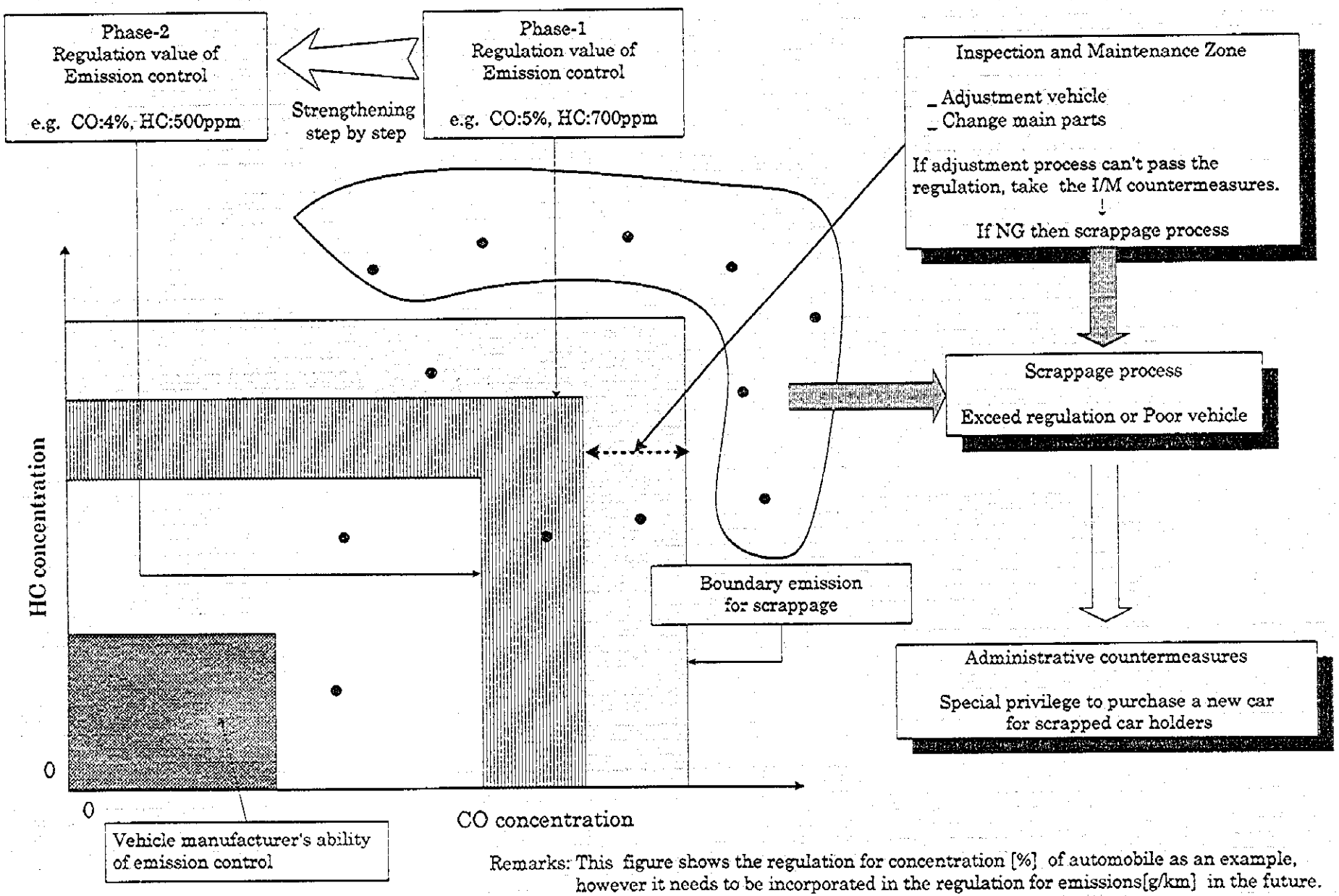
As for the age distribution of existing cars, cars of 16 - 22 years old occupy the largest proportion and the average age is 15.9. More than a half of these cars are Paykan cars as shown in Figure 3.3.1-4. Although old cars can maintain their performance to a certain degree by inspection and maintenance, restrictions on cars over a certain age as well as their replacement with new cars clearing the latest emission standards are desired based on the following grounds:

- In the phase of introducing emission standards, in-use cars do not clear the requirements.
- In-use cars do not meet the latest automobile technology which seeks to reduce air pollution.
- In-use cars cannot be equipped with supplemental parts for reducing emissions on account of the limits in specifications.
- Safe driving and fuel efficiency are sacrificed on account of the shorter durability of devices and parts.
- Basic performance is not good (Horsepower, carrying capacity, operation comfort).

■Retirement of cars

Retirement may be effectively combined with periodical inspection and maintenance of vehicles. For example, restrictions can be applied to vehicles when the emission measurement (density measurement for emissions such as CO, HC and NOx) does not meet the standards during the inspection and maintenance check, or when the vehicle does not clear the specified requirements of the inspection and maintenance item.

Fig.6.2.3-4 shows the concept of automobiles scrappage combined with maintenance.



Remarks: This figure shows the regulation for concentration [%] of automobile as an example, however it needs to be incorporated in the regulation for emissions[g/km] in the future.

Fig. 6.2.3-4 The concept of the car scrappage programme and introduction of emission regulation

Another alternative is to raise the tax or insurance premiums for vehicles over a certain age, as well as to allow new vehicles to defer their inspection and maintenance.

However, rigorous restrictions on old cars could mean that the citizens are deprived of their transportation means. Therefore the implementation of the restrictions needs to be carefully considered. Some privileges should also be given encouraging those who have been deprived of their transportation means to use the public transportation.

As for a measure to promote scrapping of old cars and purchase of clean new cars, steps taken in Greece may provide a good example. In Greece, when owners of light-duty trucks or private cars, with a displacement of less than 2,000 cc, buy clean new cars and scrap their old cars at the same time, they can receive a 50 to 60 % tax reduction when purchasing the new car and also enjoy the privilege of road tax exemption for five years (1990).

As a result, vehicle purchasers who qualify for the system can get a new car at costs 25 % lower than the normal market price. The effectiveness of this measure has been proven as 17 % of the total passenger cars were scrapped and replaced with clean ones in 1990, and the rate reached 30% in 1993.

The CO and HC emission levels were reduced 23 % and 10 % respectively, and NOx levels increased only 5 % (previously 15 % per year) after the introduction of the system.

The important point here is that the primary factor in Greece great success is that every new car which replaced an old car met the emission level requirement, which means unless the models should meet the standards, the measure would not be effective. Therefore, when the system is applied in Iran, quick introduction of emission regulations and establishment of an industry which produces vehicles meeting emission standards are necessary.

(9) Low emission vehicle propagation project

As discussed previously, while effective traffic management system for reduction of vehicle emission should be promoted, implementation of individual projects would not be efficient without links with each other. For example, vehicle inspection without maintenance follow-up would be meaningless; scrapping costs per unit quantity of emission to be reduced (US$8000/ton-CO reduced) would be more expensive than complete maintenance of in-use vehicles, (US$450/ton-CO reduced); and replacement of high-aged vehicles with medium-aged vehicles should be combined with a scrappage program.

Fig. 6.2.3-5 shows indicative project components, which include followings;

- Improvement of a periodical vehicle driving certification system
- Improvement and complete execution of vehicle inspection linked with compulsory vehicle maintenance requiring penalty payment for failure of maintenance
- Improvement and strengthening of maintenance activities
- Opening of banking accounts for procurement of a lower emission vehicle including new vehicles for a taxi and/or private vehicle

  Among incentives to be given to owners of high-aged vehicles for purchasing more ecological ones, compulsory opening of banking accounts systems linked with the I/M program should be introduced as shown under the heading of 'Banking account for green car purchase' in Fig.6.2.3-5. In the systems, a more attractive interest rate and an economical purchasing price should be offered in replacing their high-aged vehicles.
- Establishment of an In-use Vehicle Sales Center linked with actual scrappage and disposal of high-aged vehicles
- Promotion of practical research and development in rehabilitation technology for an in-use vehicle
- Establishment of an environmentally and economically beneficial system for the "Low emission vehicle propagation project"

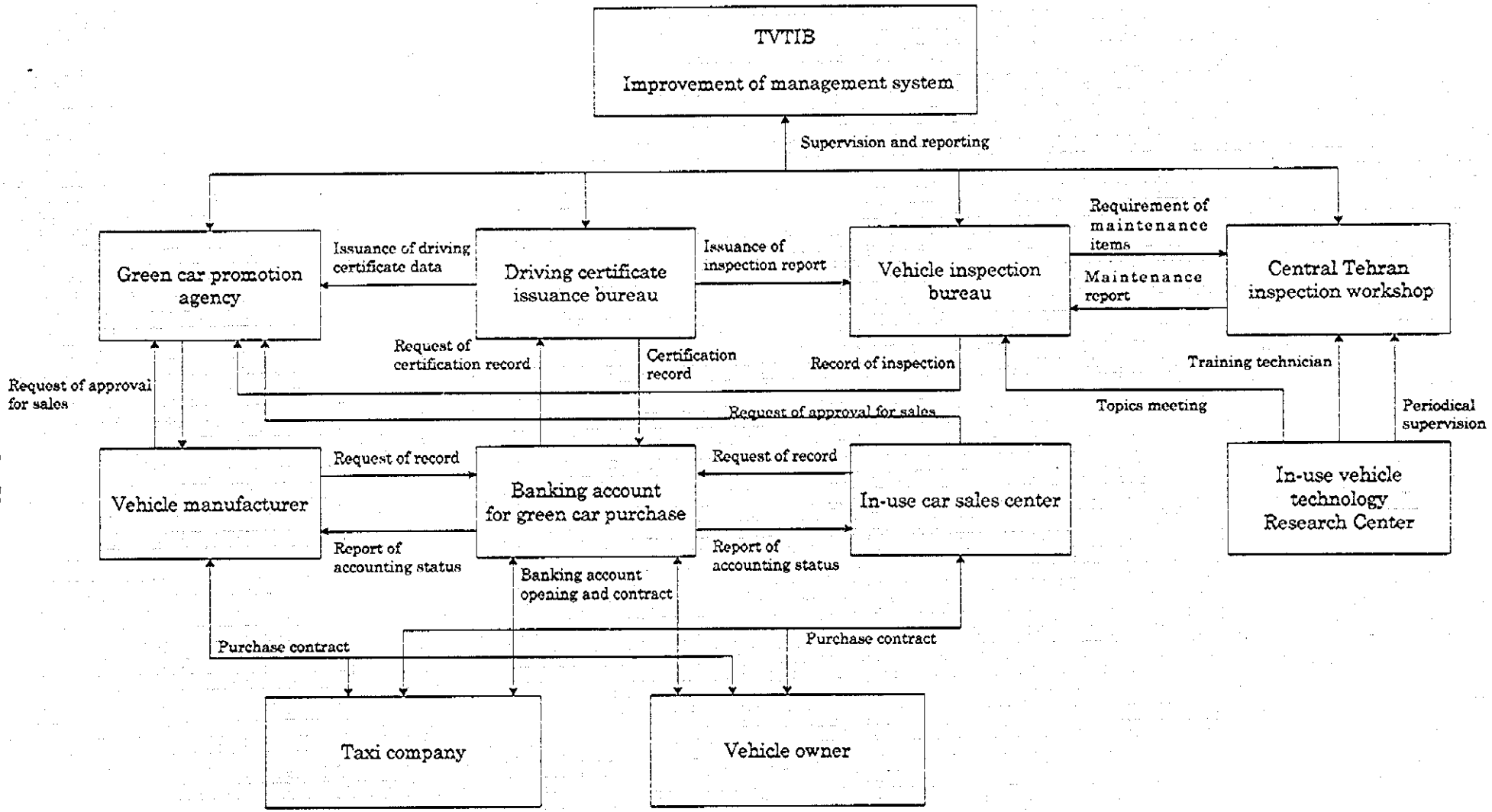


Fig. 6.2.3-5 Low emission expansion project

Key considerations for the projects are as follows;

1) Methodology for giving incentives to vehicle owner

Some benefits will be granted to the owner intending to get a more ecological vehicle, e.g. replacing a 20 year old car by a 15 or 10 year old car, in the form of payments for the vehicle or a coupon for gasoline and the like.

2) Manufacturing of new vehicles

The required number of new vehicles should be procured through an international tender inviting, among others, joint ventures of Iranian auto manufacturers possibly under the supervision of an international organization.

3) In-use Vehicle Sales Center

At present, in-use vehicles are traded in free markets without any national or Municipal authorization. In view of the present high CO/HC concentration in the ambient air, however, some kind of an in-use car sales center shown in Fig.6.2.3-1 should be established and supervised until CO pollution has been satisfactorily reduced. The Center should be controlled by the Vehicle Inspection Bureau which determines selling price of in-use vehicles in connection with the I/M program.

4) Necessities of establishment of new municipal organization and increase in man-powers

Though there are already a considerable number of man-powers and departments under the DTT of MOT, investment policy of organizations dealing with new car procurement and research in in-use vehicle technology need to be established in a stepwise manner.

According to a preliminarily calculation, benefits of CO reduction are expected to be huge, and in about around ten years the project will nearly solve the CO problems.

6.2.4 Strengthening vehicle-related technology

(1) Improvement of vehicle engines

The survey revealed that most popular vehicle engine in Iran shall be commented as below:

Combustion efficiency

The combustion efficiency and temperature of the engines as well as the power in a car is low. Naturally, the throttle has to be stepped upon harder as speed is increased or when going up a slope, which produces larger amount of emissions.

Oil separator

The capacity of the oil separator is small, and amount of blow by gas is large.

Engine revolutions

On account of the unstableness of the air fuel ratio, combustion is inefficient, and the rpm rises when the engine is idling. Large friction between working parts also makes the rpm higher. The higher the rpm, the lower the combustion efficiency, which leads to increased fuel consumption and increased pollutant emissions when the engine is idling.

Taking these problems into consideration, an improvement of the engine will be proposed as shown in Table 6.2.4-1.

(2) Improvement of the technology for the main parts of vehicle

1) Improvement of the intake system

Carburetor

Iranian vehicles are equipped with carburetors designed by Stronburg 30 years ago. They were also once used in Japan, but was stopped in 1974 because it was concluded that those carburetors were an impediment to reducing emissions.

The concrete problems created by using the carburetor are as follows:

-Engine revolutions are only stabilized between 1000 to 1100 rpm while idling and emissions become larger. The vibrations of the car body and engine become stronger while idling.

-On account of the vibration the needle in carburetor is soon worn-down, and the air fuel ratio becomes rich.

Table6.2.4-1 Modification of most popular vehicle engine in IRAN

Items	Measures	Application		Effect	Expense
		new	used		
(1)Engine modification 1) Improvement of combustion chamber	①Modify the chamber so as to reduce its wall surface (HC) ②Modify the chamber with adoption of so as to enhance swirl / new engine) tumble (CO, HC) ③Lower the combustion temperature by reducing compression ratio(NOx)	possible	possible	CO:-50% HC:-25% NOx:0%	15USS (Cost is low with adoption of new engine)
2) Optimize valve timing	Lessen overlap of intake~exhaust valve to reduce the blow of unburned gas.(HC)	possible	possible	HC:-25%	4USS (Cost is low with adoption of new engine)
3) Prolong piston stroke	①Lower the combustion possible impossible temperature by reducing rpm(NOx) ②Modify the chamber so as to reduce its wall surface (HC)	possible	possible	NOx:-20% HC:-25%	Extra cost with adoption of optimal new engine.
(2) Exchange fuels or use other type of engine 1) Use CNG, LNG engines 2) Use LPG engine	Use natural gas & LPG gas that is easy to get in Iran as fuel for the modified or new engines, promoting the use of them. (CO, HC) (No plan for introducing LNG in Iran)	possible	possible	CO:-30% HC:-80% NOx:-70%	300USS For LNG in process of study in world wide level.

-Vacuum piston diaphragm tears, and air fuel ratio becomes lean.

-Without acceleration pump, the throttle has to be stepped upon firmly and thus produces increased emissions.

-Particles in the air enters the carburetor and throttle system is worn-down.

Air cleaner

The capacity of air cleaner used is extremely small, especially, with an exhaust amount capacity of 1600 cc cannot provide a corresponding amount of fresh air.

The concrete problems are as follows:

-Intake pressure changes frequently, and the air fuel ratio varies to a great degree.

-By taking in particles in the air clogging occurs, and air intake becomes insufficient, which lower the power. Consequently, the throttle has to be stepped on firmly, which produces a larger amount of emissions.

Intake manifold

The length of intake manifold is extremely short, which makes it difficult to distribute the proper amount of mixing air into the four cylinders, and the mixing airs in the two central cylinders become rich.

2) Design defects of the ignition system

Distributor

In spite of using the contact-type distributor, no measures for preventing intake of foreign particles have been taken. Also no measures have been taken for improving the durability of the material used for the contact points; wear of this part is noted to a degree.

Taking these problems into consideration, an improvement of main parts will be proposed as shown in Table 6.2.4-2.

(3) Introduction of a catalyst

In order to reduce the amount of CO and HC in vehicular emissions, installation of a two-way catalyst in the exhaust system is very effective. If, however, the two-way catalyst is installed in a system of the vehicles, which use leaded gasoline, the catalyst deteriorates because of lead and soon loses its cleaning power. Accordingly, in order to use the two-way catalyst as a countermeasure for reducing CO and HC, unleaded gasoline should be used.

Table6.2.4-2(1) Modification of engine parts for most popular vehicle in IRAN

Items	Measures	Application		Effect	Expense
		new	used		
(1) Add intake manifold heat-riser	Improve distribution of mixing air and A/F accuracy by heating the diverging point of intake manifold, . (HC,CO)	possible	(possible)	CO:-35% HC:-15% NOx:0%	100US$
(2) Add hot air system	Keep a fixed intake temperature including cooling time to secure fuel atomization, . (HC,CO)	possible	possible	CO:-35% HC:-15% NOx:0%	100US$
(3) Add PCV system	Make oil-breather in crankcase breath into intake side without emitting substance outside.	possible	possible	HC:-15%	6US$
(4) Optimize the volume of air cleaner case and length of diameter of suction pipe.	Lessen internal pressure fluctuations of air cleaner intake to control A/F fluctuations. (HC,CO)	possible	possible	CO:-35% HC:-15%	10US$
(5) Add EGR system (exhaust recirculation)	Back a part of exhaust to intake system reducing heat per gas amount to lower the combustion temperature.(NOx)	possible	possible		<mechanical type> 25US$ <electronic type> 50US$

Table6.2.4-2(2) Modification of engine parts for most popular vehicle in IRAN

Items	Measures	Application		Effect	Expense
		new	used		
(1) Improvement of distributor 1) Idle retard	Raise exhaust temperature and keep heat in exhaust port to reduce emissions (HC,CO)	possible	possible	CO:-35% HC:-15% NOx:0%	1USS
2) Best matching of advance. Reduce permissible inequality	①Set governor/vacuum targeting best combustion in engine revolution/load. ②Reduce emission inequality for each car caused by advance inequality. (HC,CO,NOx)	possible	possible	CO:-35% HC:-15% NOx:0%	1USS
3) Full transistor	Improving control accuracy and durability. (HC,CO,NOx)	possible	possible	CO:-35% HC:-15% NOx:0%	6USS
(2) Improvement of spark plug 1) Mounting position	Set spark plug nearest a position to equalize spark transmission. (position in the center part as much as possible)	possible	impossible	CO:-35% HC:-15% NOx:0%	8USS
2) modifying electrode	Enhance capacity of spark energy (multipolarized / round face electrode etc.) (HC,CO)	possible	possible	CO:-35% HC:-15% NOx:0%	1USS

Table6.2.4-2(3) Modification of engine parts for most popular vehicle in IRAN

Items	Measures	Application		Effect	Expense
		new	used		
(1) Improvement of carburetor or adopt other types 1) Improve setting and reduce A/F inequality.	①Lean carburetor to the fixed limitation. Improve transient response. ②Reduce emission inequality for each car caused by A/F inequality. (HC,CO,NOx)	possible	possible	CO:-35% HC:-15%	30US$
(2) Addition of carburetor supplement device 1) Add engine work correspond A/F control device ①Start opener ②Automatic choke with complete explosion opener ③Decelerate opener & dash-pot ④Accelerate pomp discharge (2 step discharge etc.)	①Compensate the difference between start A/F and theoretical mixing A/F to secure initial explosion and prevent abnormal emission. ②A/F compensation control according to engin's heat. ③Prevent fire caused by ηv drop at deceleration. ④Prevent leaning caused by leak in acceleration. (CO,HC)	possible	possible	CO:-35% HC:-15%	25US$
2) Add high altitude correspond A/F control device. ①Setting at high altitude ②High altitude A/F adjustment device	①Set according to the average altitude in Tehran. ②Compensate A/F with atmospheric sensor (CO,HC)	possible	possible	CO:-35% HC:-15%	25US$
3) Add shed (prevention of evaporation gas) prevention evice ①Slow/main cut solenoid valve ②Air bent cut solenoid	Cut off float chamber passage with engine off to reduce evaporation gas. (HC)	possible	possible	HC:-15%	10US$

Table6.2.4-2(4) Modification of engine parts for most popular vehicle in IRAN

Items	Measures	Application		Effect	Expense
		new	used		
(3) Exchange Stronburg type carburetor (diaphragm/ needle jet) to other type carburetor 1) Fixed venturi type carburetor	Improve A/F stability and durability by adopting fixed venturi / jet.	possible	possible	CO:-35% HC:-15%	30US$
2) Piston type variable venturi carburetor	Inferior to fixed venturi type, but effective as a measure for motor cycle emission	possible	possible	CO:-35% HC:-15%	20US$
3) Exchange electronics control feedback carburetor.	Using O_2 sensor, work electronics device to control theoretical A/F.(CO,HC)	possible	possible		100US$
(4) Adopt electronics fuel injection (EFI)	Using O_2 sensor and other sensors, control injector via computer to control theoretical or map A/F. (CO,HC)	possible	possible	CO:-95% HC:-96% NOx:-92%	200US$
(5) Enhance the capacity of carburetor heat insulator.	Prevent A/F rich condition caused by overheated fuel.(HC,CO)	possible	possible		4US$
(6) Improve fuel pomp and regulator	By reducing combustion pressure fluctuation, control fluctuation of float oil surface to stabilize A/F.(HC,CO)	possible	possible		10US$
(7) Add canister system	Prevent evaporation gas leak from fuel tank.(HC)	possible	possible		30US$

Assuming that unleaded gasoline is used, an introduction of a two-way catalyst will be recommended as one of the countermeasures for reducing the amount of CO and HC emissions as Table 6.2.4-3 shows.

(4) Training technicians for car maintenance

For thorough inspection and maintenance of vehicles in MOT, the current number of inspection and maintenance facilities and technicians as well as the level of technology is not sufficient. The following measures, therefore, are recommended:

- Establishment of training centers
- Creation of a proper curriculum
- Introduction of the certificate system

For establishing a thorough inspection and maintenance system for vehicles, training of car engineers is indispensable. Inspection and maintenance facilities should be obligated to employ qualified car engineers. The technical standard of the facilities should be elevated by staff engineers who have thorough knowledge in vehicle technology. For training of qualified engineers who will deal with the technical vehicular matters, the establishment of training centers, provision of engineer training courses and improvement of educational facilities are indispensable.

For example, it is necessary to establish a public or private specialized school for car maintenance and inspection. In order to carry out the regular inspection and maintenance items shown in Table 6.2.3-1～2, the school should the training period for 1 to 2 years. Furthermore, the authorized qualification should be given to graduates.

(5) Establishment of a car engineering center

The national organizations carrying out vehicular studies, include MOI and MOO (NIOC, RIPI). In MOT, AQCC and TVTIB are in charge of the study, while the

Table6.2.4-3 Modification of engine parts for most popular vehicle in IRAN

Items	Measures	Application		Effect	Expense
		new	used		
(1)Add thermal reactor	Add thermai reaction room to exhaust system, and keep burning temperature high	possible	possible	CO:-35% HC:-15%	20US$
(2)2 way catalyzer	Oxidize CO and HC by using catalyzer	possible	impossible	CO:-95% HC:-96%	100US$
(3)3 way catalyzer	Keep A/F theoretical value, and oxidize CO, HC, deoxidize Nox	possible	impossible	CO: -95% HC: -96% Nox: -92%	125US$

private organizations including AIRIC, IROST, Iran Khodro, and IDEM have the division of the field. Currently, each above-mentioned institution is individually carrying out their studies with their own features. Now an integrated institution to conduct studies aiming at prevention of air pollution needs to be established.

Such studies reveal scientific views required for proper administration of the environmental activities relating to vehicles. In addition, the institution can support the implementation of countermeasures for prevention of vehicular pollution from a scientific and technological viewpoint. In the light of the current state of air pollution in Tehran, the study on the following items should be started urgently:

■ Improvement of car maintenance technology

The institution is to aim at improving the technology of car inspection and maintenance and set forth checking items, improve emission measuring technology, and review the checking procedure in order to enhance effectiveness of the operation.

■ Development of comprehensive technology for low-pollution car

■ Improvement of main parts manufacturing

Development and studies in comprehensive technology concerning a low-pollution engine, better auto-parts and better fuels are to be carried out targeting reduction of vehicle emissions. The studies to promote the use of low pollution vehicles with high technology including fuel switch over from gasoline to gas, electric cars, natural gas cars, methanol cars, and hybrid cars.

■ Learning from advanced countries

Even developed countries have had to make efforts for 20 to 30 years to improve technology for reducing vehicle emissions and introduction of the emission standards.

By actively taking in the foreign technology and know-how that have been already developed, prompt actions should be taken to cope with air pollution, reduce cost for

human resource and save time for development of technologies. Also this experience gives the nation a good opportunity to devise another creative idea on the basis of introduced foreign technology.

(6) Promoting international cooperation

As mentioned in the previous section, the cost for human resources and time can be saved by introducing the foreign technology developed in many countries which have been engaged in the ODA (Official Development Assistance) projects. Some components of ODA projects provide assistance for training of persons who are going to take initiatives in development efforts, accepting trainees from developing countries or sending engineers to these countries.

■ Accepting the engineers from the advanced countries

■ Sending the trainees to the advanced countries

It is desired to actively take advantage of the technology assistance of ODA projects, which will contribute to improvement of technology and promotion of necessary studies.

6.2.5 Fuel improvement

(1) Improvement of fuel quality

According to NIOC, most properties of the fuel, such as density, a distillation, amounts of sulfur, gum contents, vapor pressure, corrosiveness, color and mercaptan, are included in the fuel characteristics checking lists. In addition, the standard properties of gasoline are changed four times a year and those of gas oil, two times, in accordance with the season. In such a way, a regular checking system for fuel quality has been established and fuel quality has been kept to a certain standard as a rule. The Iranian standards for vehicular fuel, however, allow a higher sulfur level in diesel fuel (gas oil) and a lead level in gasoline compared to the standards established in other countries as mentioned in section 4.4.3.

International forums for protection of the earth's environment has already made considerable achievements in reducing CO and now focuses more on protecting the ozone layer from destruction and alleviating the greenhouse effect which will cause global warming, as well promoting studies for improving fuel quality, including those for reducing CO_2 emissions. In this respect, fuels in Iran have been less improved than those in other countries. Therefore, as a first step, measures for reducing CO should be urgently taken in Iran, and should be followed by other measures to keep up with other countries. For this aim, quality control and improvement of fuel properties are necessary.

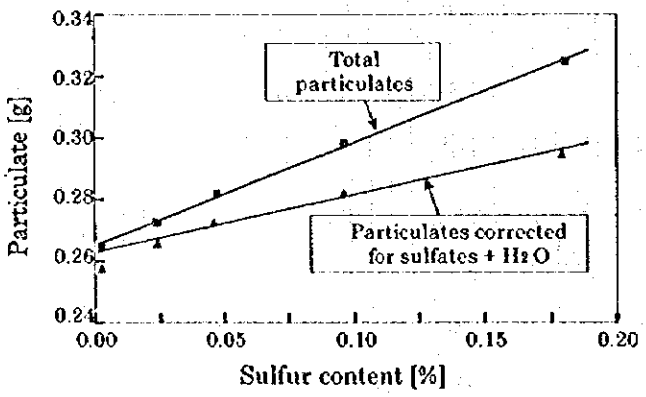
Efforts to improve fuel quality are now being made by MOO and NIOC. Operations for this objective will start at the Arak and the Bandar-Abbas plants to produce high octane fuel as the first step toward more use of unleaded gasoline in order to set the stage for introducing oxidation catalysts. It is also expected that the Bandar-Imam petro-chemical plant and the Khark Island plant will start producing MTBE as a countermeasure for reducing CO and HC.

(2) Outline of desulfurization

According to MOO's fuel quality data (Refer 4.3.3(1)), the sulfur content in Iranian gasoline is 0.1 %wt max. Sample analyses, however, have indicated that the sulfur content in the gasoline actually distributed is very small, almost the same with the world's standard. Though the sulfur content in gas oil in Iran is 1.0 %wt max, it is larger than in other countries, as indicated in Table 4.3.3-1.

Sulfur in gasoline causes higher CO, HC and NOx in exhausts, and that in diesel fuel causes particulate matters (See Figure 6.2.5-1) and greatly deteriorates the devices, such as the EGR device and oxidation catalyst used for reducing exhaust. Accordingly, measures should be taken to reduce the sulfur content to the world's standard of 0.05 to 0.1 %wt.

Fig. 6.2.5-1 Effect of sulfur on particulate matter



Data source: SAE No.932685,
Society of Automobile Engineering of Japan

(3) Diesel oil desulfurization plant

1) General description of process

A hydro-desulfurization (HDS) plant is designed to remove sulfur and nitrogen through hydrogenation from the diesel oil coming out of a crude oil topping facility as well as from the light recycling oil coming out of a fluid catalytic cracking facility. (FCC) The designed feeding capacity is 10,000 BSD in terms of diesel oil.

The mixture of oil and gas heated up to the reaction temperature by a heat exchanger and heating furnace reacts with hydrogen in a reactor, so that sulfur and nitrogen will be removed in the forms of hydrogen sulfide and ammonia. After going through this reaction, oil is cooled and taken out as final product as a result of separation of the liquid from the gas. The separated gas is sent to a sulfur recovery tower by way of an amine absorbing tower.

The sulfur recovery plant oxidizes a third of the hydrogen sulfide sent from the HDS plant into sulfur dioxide, with which hydrogen sulfide reacts to recover the sulfur element. The exhaust gas that has not been condensed in the HDS plant is discharged to the atmosphere through a tail gas treatment facility and an incinerator.

2) Facilities within battery limit

2-1) HDS plant

a) The HDS plant for intermediate oil with the capacity of 10,000 BSD (Barrels per day)

b) The amine treatment facility for the recycling gas and off gas

c) The sour water stripper

d) The tail gas treatment plant

In addition to the above, the PSA facility is to be installed to supply hydrogen meeting the requirement of the HSD plant.

2-2) Utilities

The following utilities are to be installed within B/L for supporting the process unit:

a) The air compressor for measurement instruments and dryers

b) The fuel storage tank for daily use and pump for recycling

c) The nitrogen gas system

d) The condensate recovery system

e) The collection/recovery system for condensed oil

f) The flaring stack and blowing down system

g) The detection and warning system for flammable gas and hydrogen sulfide

h) The paging and telephoning system

i) The power transformation/distribution system

j) The satellite measurement instrument room (DCS)

k) The waste water treatment system

3) Construction costs

a) License and basic engineering US$ 3,200,000

b) EPC US$ 35,000,000

4) Design specifications

a) Capacity: 10,000 BSD

b) Product to be supplied:

Diesel oil to be produced by a crude oil topping facility: 10,000 BSD

c) Sulfur content in the oil to be fed: 2.2%

d) Sulfur content in the diesel oil to be produced: 0.05% (maximum)

e) Make-up hydrogen source: hydrogen to be produced within the refinery

f) Sulfur volume to be recovered: 34 MT/yr.

g) Purity of the sulfur element: 99.8%

5) Characteristics of process

a) The sulfur content in the diesel oil to be produced at 0.05% (maximum) is well below the ceiling of 0.5%, which is based on the worldwide trend for the purpose of pollution control.

b) The heating furnace uses a low NO_x burner in consideration of needs for the ambient air pollution.

c) Because the exhaust gas out of the sulfur recovery plant is discharged after going through a tail gas treatment facility and incinerator, the SO_2 concentration and H_2S concentration in the exhaust gas are reduced to 186 PPMV and 10 PPMV respectively.

d) The process is designed to save energy.

e) Oil is recovered from the condensed oil, which is produced within the B/L.

6) Guaranteed performance

a) Production volume: 10,000 BSD

b) Sulfur content in the product: 0.05% (maximum)

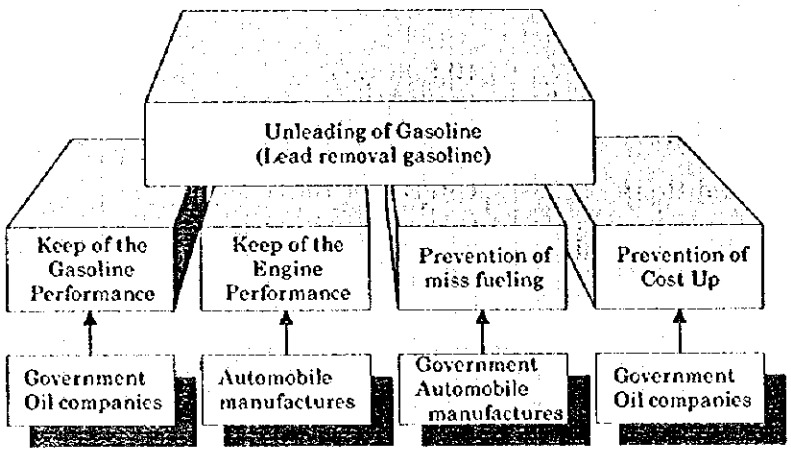
c) Hydrogen consumption: 180 SCFB (maximum)

d) Life of initially charged catalyst: 24 months (minimum)

(4) Introduction of unleaded gasoline

Lead is added to gasoline in order to enhance anti-knock performance. Lead in exhaust emissions is, however, harmful and lead oxides harm the catalyst, leading to its deterioration. Accordingly, many countries, which are carrying out measures to reduce automobile exhaust levels, are trying to reduce the lead content in gasoline, and in many cases, control the amount of lead at 0.013 g/liter or less by regulations.

Unleaded gasoline is indispensable for the future introduction of devices for reducing exhaust such as an oxidation catalytic converter and a Rhodium catalytic converter (a three-way catalyst). Although introduction of unleaded gasoline is urgently needed, it would not be feasible without comprehensive technical supports relating to production of vehicle engines, fuel, parts and catalyst as illustrated below:



As for the policy of introducing unleaded gasoline, the following measures should be taken by the national government, oil companies and vehicle manufacturers:

1) To improve gasoline performance while lowering the octane number

_ To adopt the alkylation method in the process of refining gasoline.

_ To mix high octane aromatic and olefin into gasoline.

_ To mix MTBE, alcohol or other fuels, which contain high octane oxygen, into gasoline.

2) To maintain engine performance

_ To improve the material of the valve seat as a countermeasure against valve seat recession.

_ To improve the spark plugs as a countermeasure against spark plug stain caused by additional aromatic.

3) Prevention of miss-fueling

The following countermeasures should be taken because miss-fueling damages an engine and catalyst:

_ Leaded gasoline should be distinguished from unleaded gasoline by stickers or other indications.

_ To modify the orifice of the filling hose.

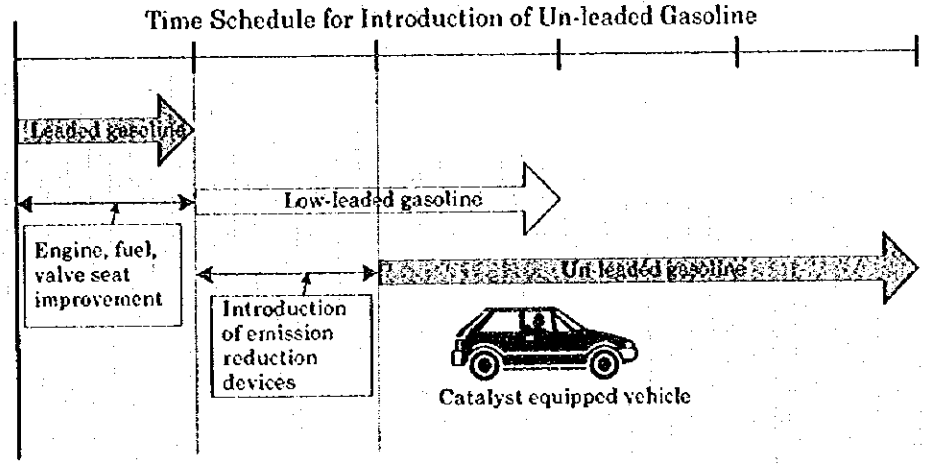
_ To fully inform car owners and gas station staff of the quality of available fuel.

4) Countermeasure against increasing fuel costs

_ To give financial support for unleaded gasoline production.

_ To give tax concessions or other incentives to users of unleaded gasoline.

Several steps should be taken before introducing unleaded gasoline as illustrated below: Pending the introduction of unleaded gasoline, a transitory period should be allowed for low-leaded gasoline by in-use vehicles. Such careful measures should also be taken as prevention of engine burning through valve recession by adding potassium to low-leaded gasoline.



(5) Introduction of oxygenated fuel

Stimulated by the passage of the Clean Air Act Amendments of 1990 in USA, oxygenated fuel started to be used worldwide from 1992. In the light of experiences since then, the application of oxygenated additives to the gasoline is the best solution to prevent the emission of carbon monoxide. In consideration of the present unsatisfactory situation of air pollution in Tehran due to emission from vehicle fleets and vehicle technology in Iran, oxygenated additives, addition of MTBE (Methyl tertiary butyl ether), a popular candidate, to gasoline should be one of means to rectify these situations in the medium run.

Therefore, MTBE production and addition to gasoline are proposed in this report.

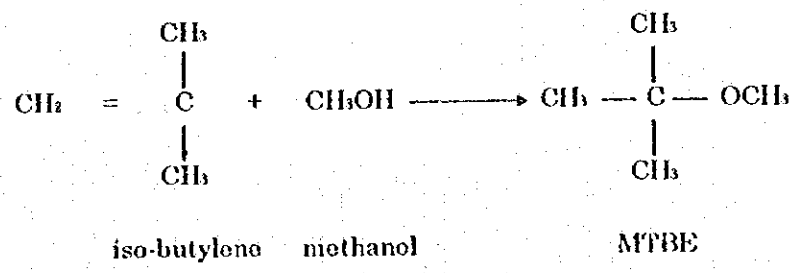
1) Advantages of MTBE blends in gasoline

Extensive use of MTBE in USA and Europe has revealed some advantages in increasing the octane number because the octane is concentrated in the front end of gasoline and, therefore, is particularly desirable for good low speed performance. Also, emissions of CO and hydrocarbons are remarkably reduced. For example, its 10% blend to gasoline leads to 16% reduction in the CO concentration in case of 5% CO contents of exhaust gas.

Meanwhile, gasoline properties such as anti-oxidation stability, storage stability, and density of gasoline do not change, and combustion materials such as NBR or fluoride rubber, polyethylene, nylon, and metallic or non-metallic materials are not produced.

2) Process outline

C_4 hydrocarbons, butadiene plant raffinate, are mixed with fresh and recycled methanol and introduced to the first reactor, in which about 90% of iso-butylene in the feed is converted into MTBE. The effluent of the first stage reactor is then fed to the second stage reactor to convert about 98% of iso-butylene.



Reaction in the both reactors is performed in the liquid phase and the generated heat is removed by circulating the reactor liquid through external heat exchangers. The 2nd stage reactor outlet stream is fed to a fractionation column for separation of C_4 raffinate. The remainder, crude MTBE, is fed to the product purification column, in which product MTBE is obtained at the column bottoms. The product purification column overheads contain a mixture of methanol and MTBE, which is recycled to the first stage reactor.

3) Specifications for cost estimate

Any process licenser normally does not issue their packages without knowing concrete site conditions including availability and properties of C_4 raffinate. Consequently, cost estimate cannot be made at this stage.

Pending determination of design specifications, internationally available information for the following will be introduced herewith;

For construction of the MTBE plant, the following detailed specifications need to be determined in conformity with the planned use of MTBE:

- C_4 feed stream
- C_4 raffinate by-product
- Net C_4 consumed
- Wt% isobutylene in feed stream
- Feed isobutylene content

4) The effect of MTBE containing gasoline and precautions in introducing the gasoline

Table 6.2.5-1 shows the effect of adding oxygenated fuel.

Table 6.2.5-1 The effect of MTBE containing gasoline clasified by exhaust system

Technology Category	Fuel	CO	HC	NOx
No Catalyst	Base	23.94	2.91	3.64
	11 vol% MTBE	19.75	2.72	3.55
	Reduction [%]	-17.5	-6.5	-2.5
Open-Loop Catalyst System	Base	13.91	0.99	2.02
	11 vol% MTBE	10.27	0.90	1.93
	Reduction [%]	-26.2	-9.1	-4.5
Closed-loop Catalyst System	Base	8.31	0.51	0.93
	11 vol% MTBE	6.30	0.48	0.90
	Reduction [%]	-24.5	-11.1	-3.2
Closed-loop Catalyst System with Adaptive Leaning Capability	Base	2.81	0.29	0.65
	11 vol% MTBE	2.74	0.27	0.67
	Reduction [%]	-2.5	-6.9	3.1
All Vehicles	Base	12.25	1.18	1.81
	11 vol% MTBE	9.77	1.09	1.77
	Reduction [%]	-20.2	-7.6	-2.2

Data Source: The Institute of Applied Energy Incorporated Foundation, 1991

Remarks:

1.Open-Loop Catalyst System: No feedback control with O_2 sensor, and equipped oxidation catalyst.

2.Close-Loop Catalyst System: Feedback control with O_2 sensor, and equipped 3-way catalyst.

3.Closed-loop Catalyst System with Adaptive Leaning Capability: Close-Loop Catalyst System added to learning performances by micro-computer.

Although various researches in oxygenated fuel has been undertaken, including Auto/Oil Air Quality Improvement Research Program (USA), these researches do not fully explain the effect of adding oxygenated fuel to gasoline for the following reasons:

- Because other characteristics of fuel (T50, T90, aromatics content rate etc.) are automatically changed by adding oxygenated fuel, it is impossible to clearly compare the case where oxygenated fuel is used with the case where it is not used.
- Because displacement systems and potential for performance vary among types of vehicles, the effects cannot be determined objectively.

Example:

The effect of oxygenated fuel on CO reduction is great in the case of vehicles with a rich air-fuel ratio, while it is small in the case of a lean ratio.

Reference:

SAE 912392: Analyzing the Influence of Gasoline Characteristics on Transient Engine Performance (Toyota)

SAE 912322: The Effect of Aromatics, MTBE, Olefins and T90 on Mass Exhaust Emissions from Current and Older Vehicles (The Auto/Oil)

On the basis of all the above-mentioned references and the results of a study by Japanese auto-makers, oxygenated fuel is considered effective in reducing CO and HC emissions in cars of a rich air-fuel ratio which do not correct the ratio with a computerized feed back system. The Japanese auto-makers' study found, however, that the amount of NOx tends to slightly increase, although the studies conducted in the USA do not clearly prove this.

It should also be noted that oxygenated fuel can affect the performance of the combustion system, and may influence the following factors depending on the fuel's nature and oxygen contents:

- Abrasion of metal rings and others

- Corrosion of metal parts in contact with the fuel
- Changes in performance of rubber and chemical products in contact with the fuel
- Production of peculiar smell.

For these reasons, it is necessary to execute wear tests and durability tests on vehicle engines and other parts before introducing oxygenated fuel. We should take into account two viewpoints to spread use of MTBE.

- The effect of CO reduction by A/F change should be tested quantitatively using vehicles in Tehran.
- The preparation should be done before adopting catalytic devices, so that the durability of catalytic devices and the exhaust and inlet valve recession problem will be overcome.

The MTBE content in gasoline is determined by the local climate, geological conditions, vehicle's engine design, the circumstances where vehicles operate and so on.

As a result, no particular percentage can be given in regard to a proper amount of MTBE content. MOO, MOI and auto manufacturers should carefully determine the content, taking into consideration the situation in other countries, where MTBE has already been introduced (ex. 7 % in Japan, and 15 % in USA).

5) Other kinds of oxygenated fuel

The study of the effect of some plant oil such as alcohol from sugar beet and rape oil for reducing CO emission is being carried out in other countries, because they contain O_2 as MTBE does and are expected to reduce CO_2. Therefore, a further feasibility study should be conducted for the purpose of protecting the global environment.

Table 6.2.5-2 lists the properties of main vegetable oils which are considered to be candidates for oxygenated fuels.

Table 6.2.5-2 Property of plant oil

	Unit	PME	Rape Oil	RME	Soybean Oil	SME	Sunflower Oil	Penut Oil
Density(15℃)	g/cm³	0.87	0.9 ~0.921	0.88 ~0.89	0.899 ~0.93	0.885	0.92	0.91
Kinetic Viscosity	mm²/s (30℃)	5.5	39 ~51.7	4.7 ~7.2	36.8/ 20℃ 71.8/ 18℃	4.2 ~4.5	67.1/ 40℃	82.3
Flashing Pt.	℃	27	320 ~330	---	---	---	---	---
CFPP	℃	11	---	---	---	---	---	---
Flowing Pt.	℃	10	15	-12	-9		-9~-4	0
Cetane No			35~40	52,54	38.5,34,41	45	33~35.5	39
Calolific Value	kcal/kg	9520	8810	8850	---	---	---	---
Oxygen Content	%		10.09	11.03				
Price	US$/kg	0.17 ~0.3	---	---	---	---	---	---

Remarks:
PME:Palm oil Methyl Ester
RME:Rape oil Methyl Ester
SEM:Soybean Methyl Ester

6) Oxygenated fuel for diesel oil

CO, HC and PM emission from a diesel oil engine can be reduced by adding oxygenated fuel to diesel oil. The oxygenated fuel to be added to diesel oil has reportedly reached a commercialization stage partially but is mostly still in a research and development stage. The research and development efforts currently focus on reduction in PM emission, which is unique to a diesel engine.

The existing research literatures both Japan and abroad are outlined below.

Oxygenated fuels for diesel oil can be made by adding oxygenated chemical compounds to diesel oil. These compounds are being used for converting such organic chemicals as pharmaceuticals and agricultural chemicals into methylic compounds as well as for widely used solvents and leaning agents. Table 6.2.5-3 lists the typical oxygenated fuels for diesel oil and their oxygen contents chosen in consideration of their availability and manufacturing costs.

Table 6.2.5-3 The typical oxygenated fuel for diezel oil

The type of chemical compounds	Content of Oxygen [wt%]	The type of chemical structure
Dietyhen Glycol Dimethyl Ether (DGM)	36	Polyether
Ethylen Glycol Mono-n-butyl Ether (ENB)	27	Polyether
Ethylen Glycol Mono-t-butyl Ether (ETB)	27	Ether alcohol
Ethylen Glycol Mono Butyl Ether Acetate	30	Ether alcohol
Propylene Glycol Mono-t-butyl Ether (PTB)	24	Ether alcohol
Di-n-butyl Ether (DNBE)	19	Ester
Dimethyl Carbonate (DMC)	53	carbonate(ester)
2-Ethylhexyl Acetate	12	Monoether

The impacts of such oxygenated fuel on exhaust gas discharging performance of a diesel engine are as follows:

1. Every oxygenated compound improves emission of THC, CO and TPM. Especially, TPM emission is substantially reduced by adding dimethyl ether (DGM) and dimethyl carbonate (DMC).
2. The larger is the impact of oxygenation, the larger is the engine load.
3. The mileage per gallon tends to decrease if oxygenated compounds are added.
4. NOx emission increases as a matter of overall tendency.

Reference: The Report related to Oxygenated Fuel for Diesel Oil,
The Institute of Applied Energy (Japan), 1995

(6) Promoting LPG and CNG

LPG (Liquefied Petroleum Gas) contains carbonized hydrogen whose number of carbon is three (propane, propylene), or four (butane, butylene) as well as their mixed substance. It is gaseous in normal temperature and is liquefied when pressurized. LPG is a by-product of gasoline and demanded for vehicular fuel as well as for households (domestic) and industrial use, although the produced amount is not as large as that of gasoline because it is a by-product.

When it was first applied for vehicular use, the latent heat in evaporation froze a vaporizer, but this problem has been cleared. The octane number of LPG is high.

LPG easily evaporates and produces the mixing air with a high air-fuel ratio (thin air) because the numbers of C and H are small. Therefore by using LPG, CO emissions are greatly reduced and hardly produced in partial load. Meanwhile, the amount of CO emissions depends on the air-fuel ratio and the CO is easily produced when load is high.

The CO pollution in Tehran is caused by engines' idling when traffic is heavy. The LPG engine, therefore, will make a great contribution to reducing CO emissions.The key issue is how many vehicles in the city will adopt LPG engines.

CNG (Compressed Natural Gas) is gaseous when it enters the combustion chamber as LPG is. Therefore using CNG is an effective way to cope with air pollution. Little CO is emitted as in case of LPG. How many vehicles in the city will adopt the CNG engines is also key.

In order to popularize LPG and CNG cars, improvement of filling facilities and vehicular performance as well as technology for cost-cutting is important. An effective way to improve filling stations is to combine regular gas stations with

LPG and CNG stations (eco-stations). In this way, existing filling stations can be utilized while saving money. It is also advantageous to build an extensive network of eco-stations.

To promote this plan, the central government and the local government of Tehran should implement a subsidy system for construction of eco-stations.

According to MOO, 240 million liters of LPG per day is provided at 11 gas stations, and 20 more LPG stations are expected to be constructed in the future. If this plan covers the improvement of eco-stations, positive effects can be achieved.

(7) The marketing policy for fuel

As for the marketing policy for fuel, stable supply of high quality fuel is crucial. Low-sulfur fuel and unleading fuel with a higher octane level and oxygen-containing fuel as well as gas fuel should be distributed at the right price. Supply of fuel which changes its property in accordance with different temperatures of each season should also be ensured.

With the improvement of vehicular fuels, several kinds of fuels will be distributed. In order to avoid confusion, fuel suppliers such as gas stations need to organize a system to supply proper fuel to each vehicle. Currently, 147 petrol stations (Refer Supporting Report Table 4.5.2.5-4(1)) and 11 LPG stations are operating in Tehran. Providing these stations' staff with information and education relating to fuel will be indispensable in order to avoid confusion. At the same time, public relations activities for car owners about fuel are important. The measures to be taken for these purpose are, firstly, to combine the existing gas stations with eco-stations which are able to supply several kinds of fuel, and secondly, to provide car owners and gas station workers with proper information about the characteristics of each fuel.

(8) Fuel price reform

As recognized internationally, Iran supplies fuel at one of the cheapest prices in the world. This is deemed as one of the reasons why severe pollution is being caused by vehicle emission and its high aged structure of vehicle fleets. The previous government endorsed the policy of encouraging ownership of one automobile per family in reflecting peoples general way of thinking of public bus service as inferiority means of transportation.

Especially prices of gasoline, LPG, natural gas and diesel are sold for surprisingly cheap prices which do not compensate even their production cost, apparently covering only 1/3 to 1/6 of the cost.

Therefore, government policy for increasing subsidized fuel prices should be continued in consideration of limited reserve of oil resources.

Under these circumstances, the Central government decided to increase the fuel price from 1994 and subsequently as well, as shown in Table 6.2.5-4.

Table 6.2.5.-4 Present fuel price policy of the Government
(Unit ; Rial/L)

	Gasoline (normal)	Premium	Diesel oil
1994	50	70	10
1995	100	140	15
1996	130	180	30
1997	160	220	30

(Source: AQCC, 1997)

The Iranian government raised the fuel price from 1994 and on March 21, 1996. The price of standard gasoline was further raised by 30% to IR 130/L, while that of super grades was raised to IR 180/L, diesel oil to IR 30/L and motor oil to IR800/L, up from IR225/L.

According to the recent analysis of the Institute for International Energy Studies of Tehran, fuel price increase has failed to cut domestic fuel consumption, but they only helped to stop rising. The observation was verified by the fact

domestic consumption has remained unchanged since 1995 at around 1.1 mb/d. Therefore, further price rises are necessary and they need to be higher than the increase currently planned by the government.

In Iran, there is no data on price elasticity with respect to the price which may be studied by the Institute for International Energy Studies, but is not being disclosed. Such studies would be needed to know effect of price increase on fuel demand. Pending these studies, the only option is to data calculated in other developing countries, according to which, the elasticity of gasoline is -1.05% as shown in Table 6.2.5-5.

Table 6.2.5-5 Fuel elasticity

		Heavy Oil	Light oil and Gas	Coal	Purchased power
Industry	Heavy Oil	-1.05	0.31	-0.41	0.02
	Light oil & Gas	1.76	-0.74	0.86	0.57
	Coal	-0.49	0.91	-1.44	1.15
	Purchased	-0.10	-0.37	0.64	-0.86
Domestic	Heavy oil	-0.80	0.57	-0.16	0.27
	Light oil & Gas	1.21	-1.29	0.30	0.02
	Coal	0.34	1.76	-0.62	1.98
	Purchased	-0.45	-0.72	0.29	-1.21

Sources: Price, Environmental Regulation & Fuel Demand,
The Energy Journal, Vol 14, Japan

Table 6.2.5-6 shows fuel consumption projection based on fuel price elasticity, under a zero inflation rate, assumed to be 1/10 if these in other developing countries in consideration of Iran's special conditions such as the present order of magnitude of fuel price, fuel consumption pattern etc.

Table 6.2.5-6 Price elasticities and GTA consumption

Fuel Type		1996	1997	2000	2005	2010
Gasoline	Consumption(1000ton/y)	7624.0	7695.7	7460.4	6915.9	6466.9
	Price(Rial/L), 3%, 20% 1/	130.0	156.0	269.6	670.8	1669.1
LPG	Consumption(1000ton/y)	369.2	372.6	361.2	336.3	313.1
	Price(Rial/kg), 4%, 20%	30.0	36.0	62.2	154.8	385.2
Natural gas	Consumption(1000ton/y)	8890.8	8974.4	8700.0	8100.1	7541.5
	Price(Rial/NM3), 5%, 10%	14.9	17.9	30.9	76.8	191.0
Diesel oil	Consumption(1000ton/y)	4288.9	4329.2	4196.9	3907.4	3638.0
	Price(Rial/kg), 3%, 20%	30.0	36.0	62.2	154.8	385.2
Heavy oil	Consumption(1000ton/y)	2372.2	2394.5	2321.3	2161.2	2012.1
	Price(Rial/kg), 2.5%, 20%	20.0	24.0	41.5	103.2	256.8

Remarks; 1/ value for growth rate of consumption and planned price increase of fuel

According to the projection consumption of all fuels increase up to the year 1997, naturally, prices of fuel should be decided in proportion to the consumer price index in the market, but gradually decrease due to the rises of fuel prices, and around the year 2010, gasoline price will reach around half a dollar which is close to the international price. In other words, fuel price increase will produce a great benefit through reduction of emission.

6.2.6 Promotion of the public environmental awareness

In the previous chapters, we have discussed the methods to improve a vehicle engine and fuel quality, as well as transportation management for reduction of air pollution. As public relations activities are also important, they will be discussed in this section.

(1) Promotion of the public awareness and public relations activities

This method aims at promoting environmental education for reducing air pollution and promoting public awareness on environment. TV campaigns and distribution of brochures carried out by AQCC and TVTIB have proved to be successful. In the future, campaigns should address the following objectives:

- Promoting use of public transportation
- Promoting ride sharing systems such as car pools and van pools
- Encouraging provision of parking places and preventing illegal parking
- Promotion of flex time
- Encouraging observation of traffic rules
- Others
  - To make maps with up-to-date information about traffic regulations and parking places in Tehran, and to distribute them to the public.
  - Environment ticket campaigns

    To distribute tickets of small sum worth which can be used for public transportation such as buses, and to promote public relations activities to encourage people to use public transportation instead of private cars.
  - To organize exhibitions and provide opportunities to experience simulated environmental conditions for environmental education.

(2) Retraining of the drivers

The objective of retraining drivers is to promote campaigns for raising environmental awareness, sensitizing people to the harm of air pollution and encouraging safe driving by car owners.

■ To provide training courses on prevention of air pollution and safe driving when drivers licenses are renewed or reissued.

■ Prevention of the pollution caused by traffic and Safety Traffic Week

For this objective, a particular period of time is to be specified so that during this period the police will tightly control traffic aiming at preventing pollution caused by traffics and traffic accidents and the information relating to the above-mentioned matters will be provided through practical training.

(3) Public campaign for reducing emissions

For this objective, public relations activities for disseminating basic information should be conducted and public awareness should be promoted. The activities should be supported by TV campaigns and distribution of brochures.

■ Encouraging to go through regular inspections and maintenance

■ Promotion of new type car sales and encouraging to scrap old cars

(4) Promotion of the use of clean fuel

For this objective, public relations activities for promoting use of low-pollution cars (LPG cars for the moment) should be conducted and clean fuel users should be provided with special services, incentives and brochures of filling stations maps.

6.3 Countermeasure for stationary source

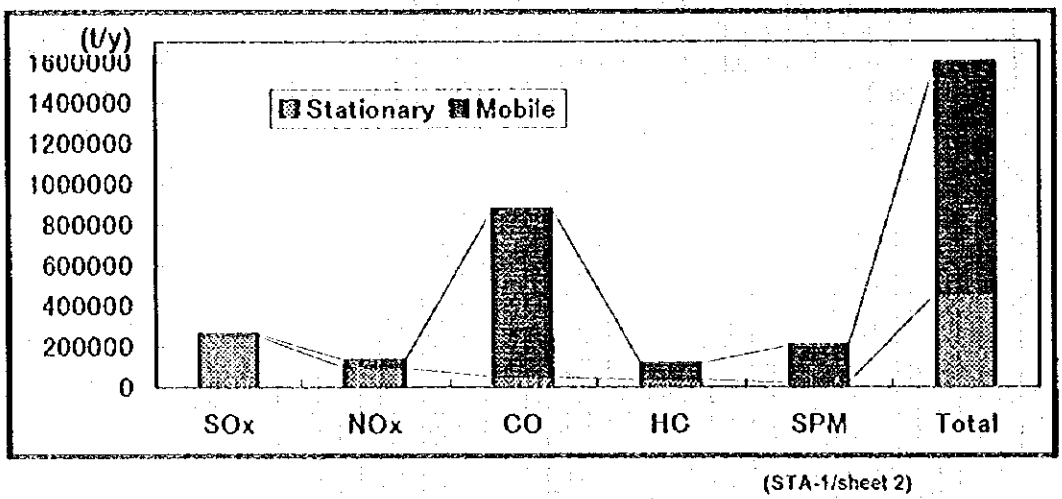
As shown in Table 6.3-1 and Fig 6.3-1, contributions of stationary emission sources and mobile emission sources to the total emission of air pollution in GTA are 29% and 71% respectively, indicating dominance of mobile sources. As for each pollutant, however, stationary sources share 97% and 71% in SOx and NOx, while mobile sources share 94%, 70% and 88% in CO, HC and SPM respectively. Therefore in this report, the countermeasures against SOx and NOx from stationary sources are focused.

Table 6.3-1 : Emission quantity of air pollutants in GTA (1994)

(ton/year,%)

Source	SOx	NOx	CO	HC	SPM	(Total)
- Manufacturing	167,923	56,541	47,536	2,948	16,906	291,916
- Commercial & Household	35,720	15,051	2,893	15,347	5,291	74,301
- Energy Conversion	50,289	23,900	953	16,401	2,836	94,380
Stationary	253,981	95,571	51,421	34,701	25,113	460,787
Mobile	8,340	39,610	826,806	81,690	182,717	1,139,163
(Sub-total)	262,321	135,181	878,227	116,391	207,830	1,599,949
Stationary	96.8	70.7	5.9	29.8	12.1	28.8
Mobile	3.2	29.3	94.1	70.2	87.9	71.2
(Sub-total)	100.0	100.0	100.0	100.0	100.0	100.0

Fig 6.3-1 : Emission quantity of air pollutants in GTA (1994)



Stationary emission control measures can be divided into : ①energy conservation and ② direct pollution control. Since there are many reports regarding large scale industries(>100 persons) and energy conversion sectors, especially with technical aspects both of energy

conservation and direct pollution control, and MOT is not in the position to take care of national matters, this report focuses on the following sectors which represent more than 50% of energy consumption in GTA.

- Small & medium size industries (≦100 persons)
- General service & households

It is also assumed that the current technical levels for energy conservation and air pollution control in Iran are nearly equivalent to those of the OECD countries in the years prior to the first oil shock (1973).

6.3.1 Long term target for air pollution control in GTA

Projection of long term emission quantities of air pollutants in GTA can be projected by the change of the following three (3) factors:

① Energy Growth factor : To be projected by average growth rate multiplied by energy conservation rate

② Emission factor : To be modified by installation of air pollution control equipment and combustion control technology

③ Fuel replacement factor : To be projected by change of fuels to natural gas

The concept of scenario for air pollution control is very briefly mentioned below, although it will be defined in details in the following sections.

- Do-Nothing: Energy conservation and pollution control measures are not positively conducted better than the current level, and pollution quantities in the future are estimated in proportion to the real economic growth rate in each economic sector, that is, extrapolating the current trend.
- Common : Intermediate reduction of pollution between "Do-Nothing" and "Best "scenario.
- Best : Reduction scenario of pollution is fully implemented as scheduled.

The other major assumptions for the scenario are as follows.

- Target year : 2010 (Base year 1994)
- Average growth rate (1994-2010) : GNP 5.1%, Manufacturing 5.9%,
  (referred to 2nd 5 Year Plan) Commercial/Household 2.6%
- Power plants & Refinery in GTA : No capacity expansion is scheduled due to environmental reasons up to 2010.

(1) Target of energy conservation

Table 6.3.1-1 : Target of energy conservation

Sector		Reduction target	
	Base	Common	Best
Manufacturing			
31 Food	100	93.40%/IIP @2010	86.80%/IIP @2010
32 Textile	100	90.55%/IIP @2010	81.10%/IIP @2010
33 wood	100	91.75%/IIP @2010	83.50%/IIP @2010
34 Paper	100	81.45%/IIP @2010	62.90%/IIP @2010
35 Chemicals	100	75.75%/IIP @2010	51.50%/IIP @2010
36 Non-metal	100	89.30%/IIP @2010	78.60%/IIP @2010
37 Iron & steel	100	85.80%/IIP @2010	71.60%/IIP @2010
38 Machinery	100	95.25%/IIP @2010	90.50%/IIP @2010
39 Others	100	95.25%/IIP @2010	90.50%/IIP @2010
Household	100	125.15%/IHS @2020	150.30%/IHP @2020
Commercial	100	89.70%/ICS @2020	79.40%/ICP @2020
Power plants	100	97.50%/IIP @2020	95.00%/IIP @2020
Refinery	100	95.00%/IIP @2020	90.00%/IIP @2020

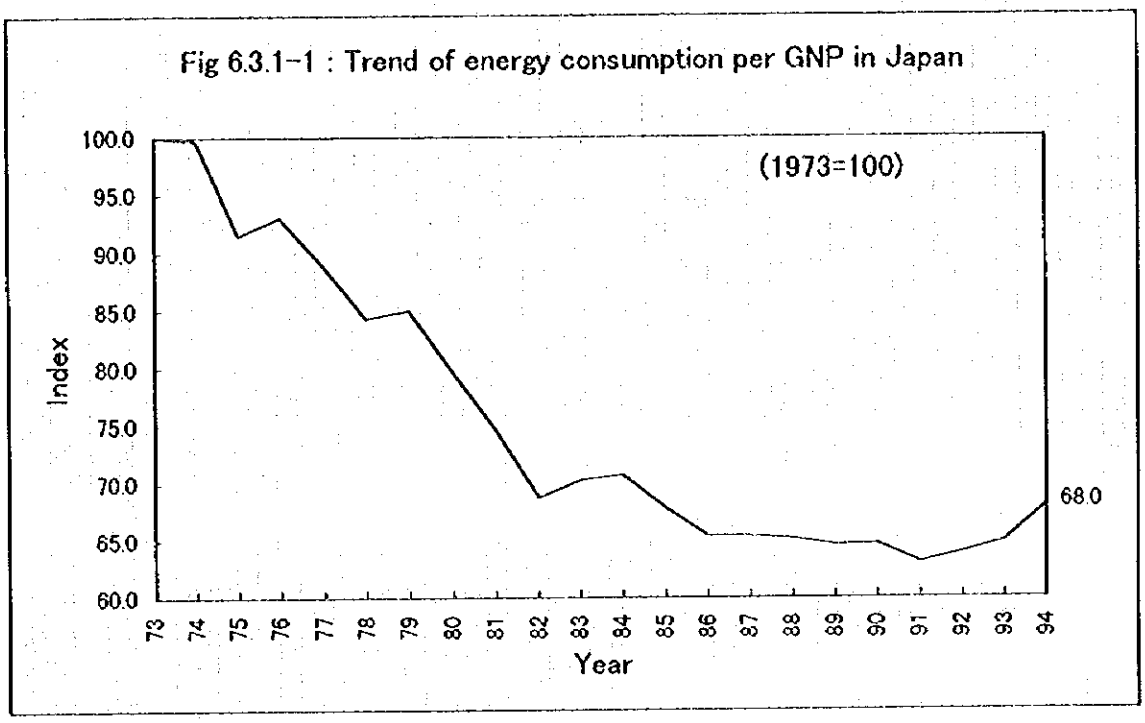
(Note) IIP:Index of Industrial Product, IHS:Index of Household Service
ICS:Index of Commercial Service

Energy conservation is equivalent to air pollution control in a sense that emission of air pollutants will decrease almost in proportion to the energy conservation ratios. The long term target of energy conservation in GTA is recommended in Table 6.3.1-1 above, which is based on the achievement in Japan as shown in Fig 6.3.2-1,-2,-3,-4 and Table 6.3.2-2. The target of the Common scenario is established as about 50% of the Best scenario while the Do-Nothing scenario means "do nothing" for energy conservation and pollution control activities.

It is widely said in the world that the energy conservation in developing countries could be achieved by 15-25% per GNP by means of strict administrative control over daily operations and maintenance activities with only negligible additional cost but that conservation of additional 15-25% per GNP would require proper investment, costing 5-10% of acquisition cost of the existing

and/or new equipment/facilities in terms of current prices.

Figure 6.3.1-1 shows the record of almost 37% energy conservation in Japan in terms of energy consumption per GNP from 1973 to 1991 and the recent aggravating trend from 1991 onward by 5%.



(Source) Handbook of energy & economic statistics in Japan

(2) Target of direct air pollution reduction

Regarding the stationary emission sources, the long term target for air pollution control in GTA is to clear the WHO quality standards in terms of SOx and NOx emission in 2010. In order to realize this objective, the following direct air pollution control is suggested:

- Fuel oil/solid fuel replacement with natural gas
- Installation of HDS and De-NOx facilities in a refinery
- Installation of De-NOx facilities in power plants

In the event that current emission factors (EF) of SOx and NOx could be reduced and fuel replacement with natural gas could be implemented according to the above measures as scheduled in Table 6.3.1-2 below in combination with energy conservation activities, the reduction of SOx and NOx emission compared to the amount of 1994 is expected as shown in Table 6.3.1-3, which would

clear the WHO quality standards in the Best scenario in 2010.

Table 6.3.1-2 : Target of stationary air pollution control

(%)

Item	Base	Do-Nothing		Common		Best	
	1994	2005	2010	2005	2010	2005	2010
Fuel oil(FO) replacement with natural gas	100	100	100	80	75	75	70
Solid fuel(SF) replacement with natural gas	100	100	100	75	50	50	0
Change of EF by installation of HDS in Tehran refinery							
- Kerosene	100	100	100	100	100	100	100
- Gas oil	100	100	100	100	10	10	10
- Heavy oil	100	100	100	100	100	100	10
Change of EF by installation of De-NOx equipment & combustion control							
- Tehran refinery	100	100	100	95	90	90	50
- Power plants	100	100	100	95	90	90	50
- Industries	100	100	100	98	97	96	95
Change of EF by De-NOx by combustion control							
- Household/commercial	100	100	100	99.5	99	99	98

(Scenario\sheet4)

(Note) EF : Emission factor

The figures in the cells of Common & Best cases indicates fuel oil & solid fuel ratios or change of EF to the corresponding figures of Do-Nothing cases

Table 6.3.1-3 : Expected reduction ratio of pollutants (%)

Item	Base	Do-Nothing		Common		Best	
	1994	2005	2010	2005	2010	2005	2010
SOx emission compared to 1994	100	163	207	121	113	85	33
NOx emission compared to 1994	100	157	197	135	153	115	114

(Scenario\sheet4)

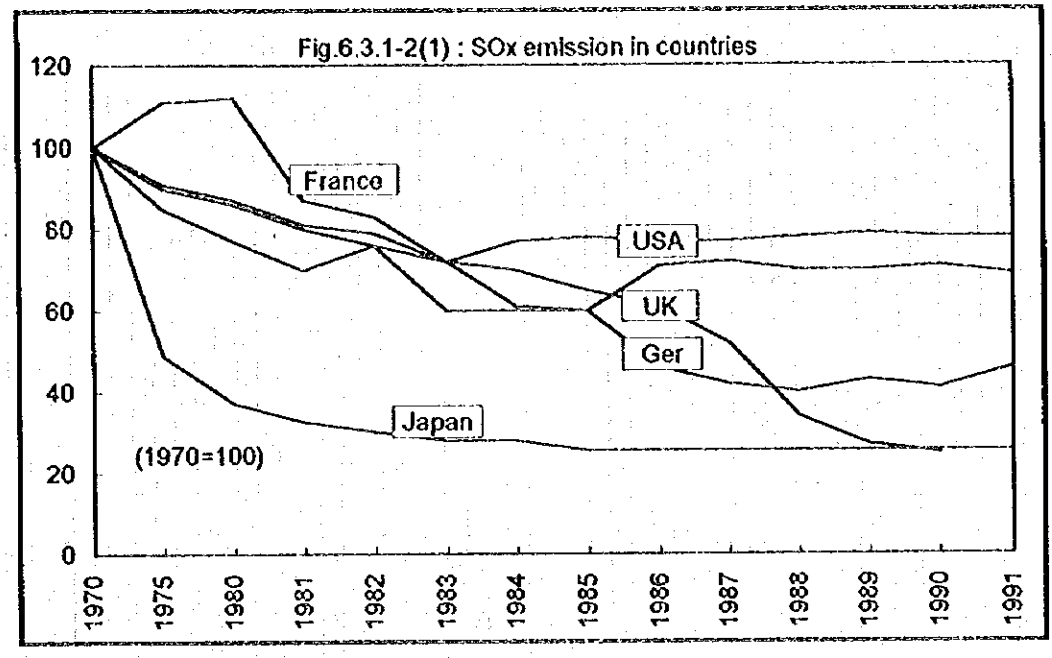
Long term targets of stationary air pollution control in GTA from 1994 to 2005 and 2010 are summarized in the above tables taking into account the results of the simulation charts and Fig 6.3.1-2 & 3, which show the reduction trend of air pollutants in OECD countries.

(3) Case study for reduction of pollutant

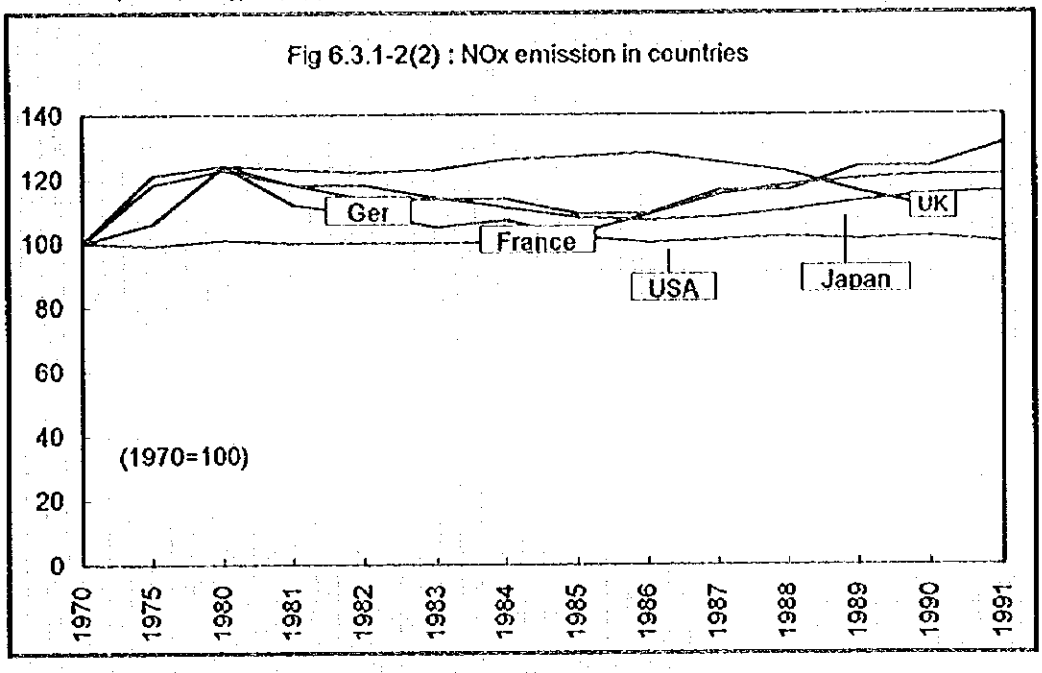
Based on the assumptions described above, emission amounts of SOx and NOx from stationary emission source are projected as follows. The details of the projection are shown in APPENDIX 6.3.1.

1) Emission quantities of pollutants in each scenario

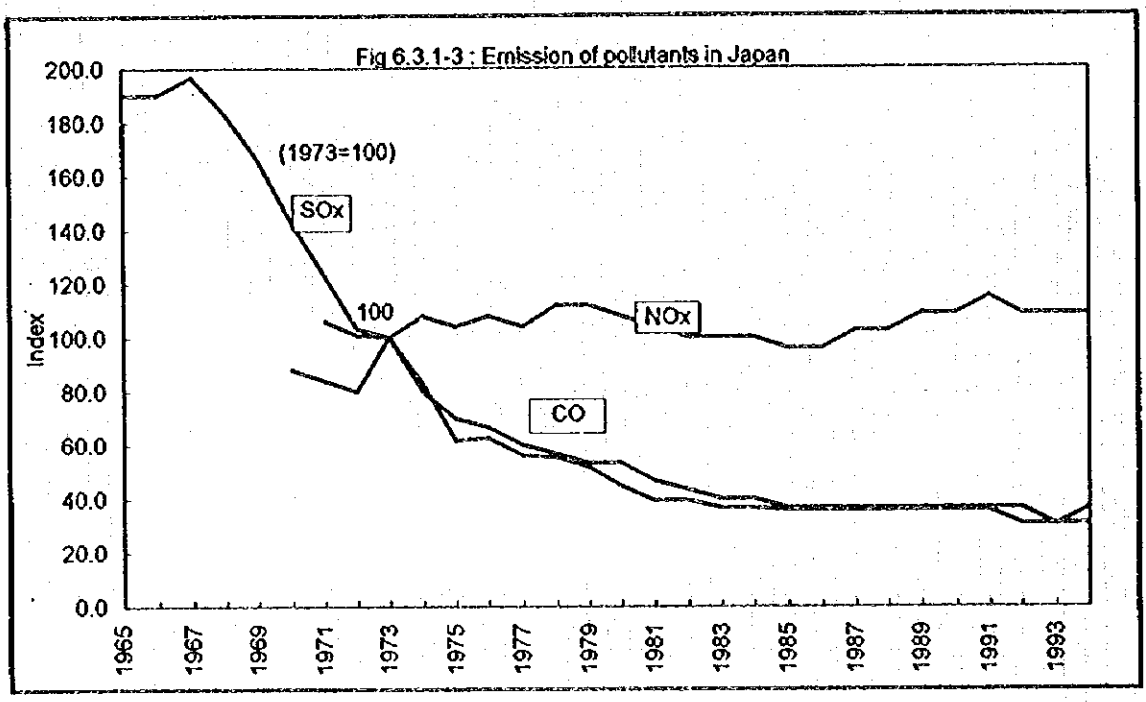
Table 6.3.1-4 and Fig 6.3.1-4 show the emission quantities of pollutants in each scenario explained above.



(Source) Energy 96 (MITI)



(Source) Energy 96 (MITI)



(Source) Energy 96 (MITI)

Table 6.3.1-4(1) : Stationary emission quantities of pollutants in each scenario (t/y)

Year	SOx			NOx		
	Do-Nothing	Common	Best	Do-Nothing	Common	Best
1994	253,981	253,981	253,981	95,571	95,571	95,571
2005	413,303	308,227	217,134	150,202	128,698	109,879
2010	524,585	286,237	83,902	188,220	146,396	109,304

Table 6.3.1-4(2) : Stationary emission quantities of pollutants in each scenario (%)

Year	SOx			NOx		
	Do-Nothing	Common	Best	Do-Nothing	Common	Best
1994	100	100	100	100	100	100
2005	163	121	85	157	135	115
2010	207	113	33	197	153	114

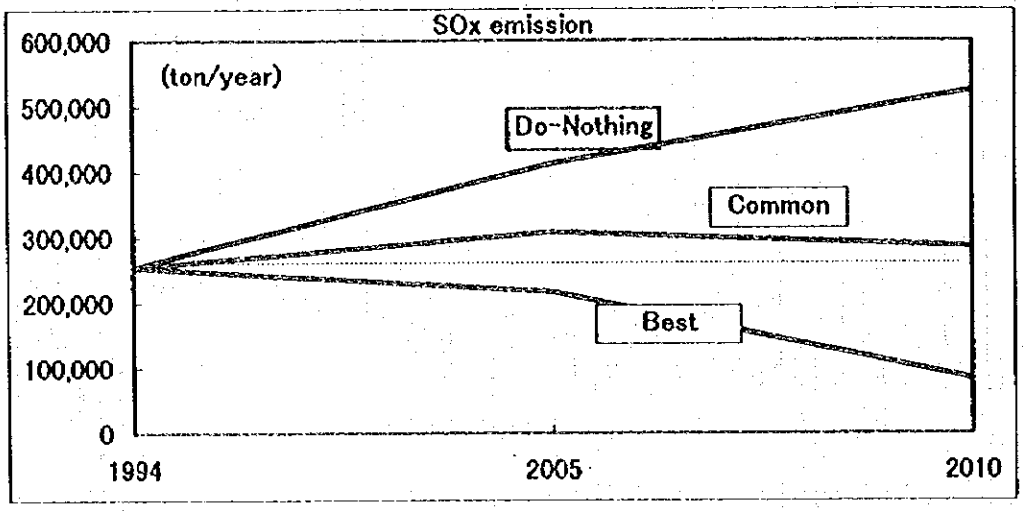
Concerning the calculation of Table 6.3.1-4 above based on the assumptions of Table 6.3.1-1 and Table 6.3.1-2, Table 6.3.1-5 and Table 6.3.1-6 are prepared for better understanding of calculation procedures.

2) Outcome of projection

As shown in Table 6.3.1.-4 and Fig 6.3.1-4, if compared to the emission amount in 1994, the Do-Nothing scenario indicates that the emission amounts both of SOx and NOx will be almost 1.5 times in 2005 and 2 times in 2010, while the Best scenario will lead to 70% reduction of SOx and slightly more level of NOx emissions in 2010. It is believed that the Common scenario may be the most likely scenario among 3 cases, which induces almost 1.1 times increase in SOx and 1.5 times increase in NOx in 2010 compared with in 1994.

There are no specifically effective countermeasures for NOx reduction as evidenced in OECD countries, such as fuel replacement with natural gas in the case of SOx. Therefore, MOT is advised to promote fuel replacement with natural gas as much as possible for SOx reduction and to keep at least the current level of NOx emission by all means as the minimum requirement for pollution control in GTA.

Fig 6.3.1-4 : Stationary emission quantities of pollutants in each scenario



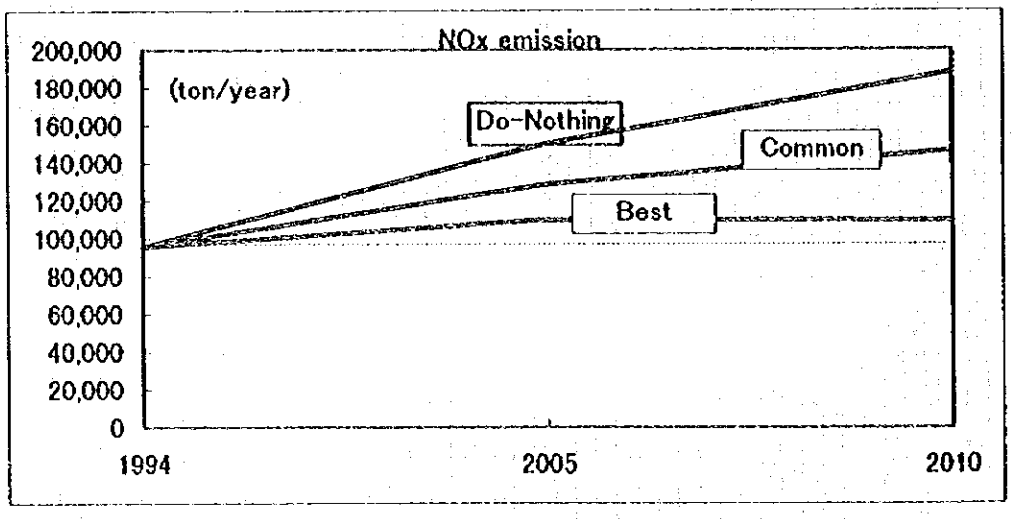


Table 6.3.1-5(1) : Energy conservation index of air pollution control scenario

Item	Growth rate & reduction target		Energy index							Energy consu		
			Base	Do-Nothing		Common		Best		Base	Do-Nothing	
	(Common)	(Best)	1994	2005	2010	2005	2010	2005	2010	1994	2005	2010
GNP	5.1%/year	5.1%/year	1.000	1.728	2.216	1.728	2.216	1.728	2.216			
Manufacturing	5.9%/year	5.9%/year	1.000	1.879	2.502	1.879	2.502	1.879	2.502			
Commercial/household	2.6%/year	2.6%/year	1.000	1.326	1.508	1.326	1.508	1.326	1.508			
Power plant	0%/year	0%/year	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
Refinery	0%/year	0%/year	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
Manufacturing												
31 Food	93.40%/IIP @2010	86.80%/IIP @2010	1.000	1.879	2.502	1.793	2.337	1.704	2.172	1387	2,606	3,471
32 Textile	90.55%/IIP @2010	81.10%/IIP @2010	1.000	1.879	2.502	1.755	2.266	1.627	2.029	721	1,355	1,804
33 Wood	91.75%/IIP @2010	83.50%/IIP @2010	1.000	1.879	2.502	1.771	2.295	1.660	2.089	65	122	163
34 Paper	81.45%/IIP @2010	62.90%/IIP @2010	1.000	1.879	2.502	1.632	2.038	1.366	1.574	267	502	668
35 Chemicals	75.75%/IIP @2010	51.50%/IIP @2010	1.000	1.879	2.502	1.552	1.895	1.190	1.289	1105	2,076	2,765
36 Non-metals	89.30%/IIP @2010	78.60%/IIP @2010	1.000	1.879	2.502	1.738	2.235	1.592	1.967	2249	4,225	5,628
37 Iron& steel	85.80%/IIP @2010	71.60%/IIP @2010	1.000	1.879	2.502	1.691	2.147	1.493	1.792	3339	6,273	8,355
38 Machinery	95.25%/IIP @2010	90.50%/IIP @2010	1.000	1.879	2.502	1.817	2.383	1.754	2.265	816	1,533	2,042
39 Others	95.25%/IIP @2010	90.50%/IIP @2010	1.000	1.879	2.502	1.817	2.383	1.754	2.265	531	998	1,329
(Subtotal)										10480	19,689	26,224
Per IIP										10480	10,480	10,480
Per 1994 (%)										100	100	100
Household	125.15%/IHS @2010	150.30%/IHS @2010	1.000	1.326	1.508	1.547	1.887	1.755	2.266	6057	8,033	9,133
Commercial	89.70%/ICS @2010	79.40%/ICS @2010	1.000	1.326	1.508	1.231	1.353	1.132	1.197	1272	1,687	1,918
Power plant	97.50%/IIP @2010	95.00%/IIP @2010	1.000	1.000	1.000	0.983	0.975	0.965	0.960	1088	1,088	1,088
Refinery	95.00%/IIP @2010	90.00%/IIP @2010	1.000	1.000	1.000	0.965	0.950	0.930	0.900	1033	1,033	1,033
(Subtotal)										9450	11,841	13,172
Per GNP										9,450	6,851	5,943
Per 1994 (%)										100	72	63
(Total)										19,930	31,530	39,396
Per GNP										19,930	18,243	17,775
Per 1994 (%)										100	92	89

(Note) IIP:Index of Industrial Product, HIS:Index of Household Service, ICS: Index of Commercial Service

Table 6.3.1-5(2) : Emission factors of air pollution control scenario

Item	Base	Do-Nothing		Common		Best	
	1994	2005	2010	2005	2010	2005	2010
Fuel oil(FO) conversion to natural gas	FO*1.00	FO*1.00	FO*1.00	FO*0.80	FO*0.75	FO*0.75	FO*0.5
Solid fuel(SF) conversion to natural gas	SF*1.00	SF*1.00	SF*1.00	SF*0.75	SF*0.5	SF*0.5	SF*0.0
Installation of HDS in Tehran refinery							
- Kerosene	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*1.00
- Gas oil	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*0.10	EF*0.10	EF*0.10
- Heavy oil	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*1.00	EF*0.10
Installation of De-NOx equipment							
- Tehran refinery	EF*1.00	EF*1.00	EF*1.00	EF*0.95	EF*0.90	EF*0.90	EF*0.50
- Power plants	EF*1.00	EF*1.00	EF*1.00	EF*0.95	EF*0.90	EF*0.90	EF*0.50
- Industries	EF*1.00	EF*1.00	EF*1.00	EF*0.98	EF*0.97	EF*0.96	EF*0.95
De-NOx by combustion control							
- Household	EF*1.00	EF*1.00	EF*1.00	EF*0.99	EF*0.99	EF*0.98	EF*0.98
- Commercial	EF*1.00	EF*1.00	EF*1.00	EF*0.98	EF*0.97	EF*0.96	EF*0.95

(Note) EF: Emission factor

Table 6.3.1-6(1) : Energy conservation scenario (Common)

	Japan	GTA	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GNP	Best	Enegy	1.000	1.051	1.105	1.161	1.220	1.282	1.348	1.417	1.489	1.565	1.644	1.728	1.816	1.909	2.006	2.109	2.216
Manufacturing	scenario	conservation	1.000	1.059	1.121	1.188	1.258	1.332	1.411	1.494	1.582	1.675	1.774	1.879	1.990	2.107	2.231	2.363	2.502
Commercial/household	in Japan	target	1.000	1.026	1.053	1.080	1.108	1.137	1.166	1.197	1.228	1.260	1.293	1.326	1.361	1.396	1.432	1.470	1.508
Power plant	(1973-1994)	in 2010 (%)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Refinery			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
31 Food	86.800	93.400	1.000	1.054	1.112	1.173	1.236	1.304	1.375	1.450	1.529	1.612	1.700	1.793	1.890	1.993	2.102	2.216	2.337
32 Textile	81.100	90.550	1.000	1.052	1.108	1.166	1.227	1.291	1.359	1.430	1.505	1.584	1.667	1.755	1.847	1.944	2.046	2.153	2.266
33 Wood	83.500	91.750	1.000	1.053	1.109	1.169	1.231	1.297	1.366	1.439	1.515	1.596	1.681	1.771	1.865	1.965	2.069	2.180	2.296
34 Paper	62.900	81.450	1.000	1.046	1.093	1.143	1.195	1.249	1.306	1.365	1.428	1.493	1.561	1.632	1.706	1.783	1.865	1.949	2.038
35 Chemicals	51.500	75.750	1.000	1.041	1.083	1.127	1.173	1.221	1.271	1.323	1.377	1.433	1.491	1.552	1.615	1.681	1.750	1.821	1.895
36 Non-metals	78.600	89.300	1.000	1.052	1.106	1.163	1.223	1.286	1.352	1.422	1.495	1.572	1.653	1.738	1.828	1.922	2.021	2.125	2.235
37 Iron& steel	71.600	85.800	1.000	1.049	1.100	1.154	1.210	1.270	1.332	1.397	1.465	1.537	1.612	1.691	1.774	1.860	1.951	2.047	2.147
38 Machinery	90.500	95.250	1.000	1.056	1.115	1.177	1.243	1.312	1.385	1.462	1.544	1.630	1.721	1.817	1.918	2.025	2.138	2.257	2.383
39 Others	90.500	95.250	1.000	1.056	1.115	1.177	1.243	1.312	1.385	1.462	1.544	1.630	1.721	1.817	1.918	2.025	2.138	2.257	2.383
Household	150.300	125.150	1.000	1.040	1.083	1.126	1.172	1.220	1.269	1.320	1.374	1.429	1.487	1.547	1.610	1.675	1.743	1.814	1.887
Commercial	79.400	89.700	1.000	1.019	1.038	1.058	1.078	1.099	1.120	1.141	1.163	1.185	1.208	1.231	1.254	1.278	1.302	1.327	1.353
Power plant	95.000	97.500	1.000	0.998	0.997	0.995	0.994	0.992	0.991	0.989	0.987	0.986	0.984	0.983	0.981	0.980	0.978	0.977	0.975
Refinery	90.000	95.000	1.000	0.997	0.994	0.990	0.987	0.984	0.981	0.978	0.975	0.972	0.968	0.965	0.962	0.959	0.956	0.953	0.950

Table 6.3.1-6(2) : Energy conservation scenario (Best)

	Japan	GTA	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GNP	Best	Enegy	1.000	1.051	1.105	1.161	1.220	1.282	1.348	1.417	1.489	1.565	1.644	1.728	1.816	1.909	2.006	2.109	2.216
Manufacturing	scenario	conservation	1.000	1.059	1.121	1.188	1.258	1.332	1.411	1.494	1.582	1.675	1.774	1.879	1.990	2.107	2.231	2.363	2.502
Commercial/household	in Japan	target	1.000	1.026	1.053	1.080	1.108	1.137	1.166	1.197	1.228	1.260	1.293	1.326	1.361	1.396	1.432	1.470	1.508
Power plant	(1973-1994)	in 2010 (%)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Refinery			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
31 Food	86.800	86.800	1.000	1.050	1.102	1.157	1.214	1.274	1.338	1.404	1.474	1.547	1.624	1.704	1.789	1.878	1.971	2.069	2.172
32 Textile	81.100	81.100	1.000	1.045	1.092	1.142	1.194	1.248	1.304	1.363	1.425	1.489	1.556	1.627	1.700	1.777	1.858	1.942	2.029
33 Wood	83.500	83.500	1.000	1.047	1.096	1.148	1.202	1.259	1.318	1.380	1.445	1.514	1.585	1.660	1.738	1.820	1.906	1.996	2.089
34 Paper	62.900	62.900	1.000	1.029	1.058	1.089	1.120	1.152	1.185	1.219	1.255	1.291	1.328	1.366	1.405	1.446	1.487	1.530	1.574
35 Chemicals	51.500	51.500	1.000	1.016	1.032	1.049	1.065	1.082	1.100	1.117	1.135	1.153	1.172	1.190	1.210	1.229	1.248	1.268	1.289
36 Non-metals	78.600	78.600	1.000	1.043	1.088	1.135	1.184	1.235	1.289	1.344	1.402	1.463	1.526	1.592	1.661	1.733	1.807	1.885	1.967
37 Iron& steel	71.600	71.600	1.000	1.037	1.076	1.116	1.157	1.200	1.244	1.291	1.339	1.388	1.440	1.493	1.549	1.606	1.666	1.728	1.792
38 Machinery	90.500	90.500	1.000	1.052	1.108	1.166	1.227	1.291	1.359	1.430	1.505	1.584	1.667	1.754	1.846	1.943	2.045	2.152	2.265
39 Others	90.500	90.500	1.000	1.052	1.108	1.166	1.227	1.291	1.359	1.430	1.505	1.584	1.667	1.754	1.846	1.943	2.045	2.152	2.265
Household	150.300	150.300	1.000	1.052	1.108	1.166	1.227	1.291	1.359	1.430	1.505	1.584	1.668	1.755	1.847	1.944	2.046	2.153	2.266
Commercial	79.400	79.400	1.000	1.011	1.023	1.034	1.046	1.058	1.070	1.082	1.094	1.107	1.119	1.132	1.145	1.157	1.171	1.184	1.197
Power plant	95.000	95.000	1.000	0.997	0.994	0.990	0.987	0.984	0.981	0.978	0.975	0.972	0.968	0.965	0.962	0.959	0.956	0.953	0.950
Refinery	90.000	90.000	1.000	0.993	0.987	0.980	0.974	0.968	0.961	0.955	0.949	0.942	0.936	0.930	0.924	0.918	0.912	0.906	0.900