6.3.2 Procedures for energy conservation and pollution control

(1) Energy conservation procedures

In Iran, although the Iranian government has started upward price adjustments, energy is still substantially underpriced relative to the international opportunity cost, giving little economic incentives to energy conservation by energy users, especially in small unit energy consumers such as small & medium size industries (≦100 persons) and commercial/household units.

Therefore, sophisticated governmental guidance and powerful top-down policy for energy conservation in these sectors are recommended. The items below indicate the fundamental and common measures for energy conservation.

①Improvement of fuel combustion

②Improvement of heating, cooling and heat transfer

③Prevention of heat loss through radiation, heat transfer, etc.

④Recovery of waste heat

⑤Improvement of conversion efficiency from heat to power

⑥Prevention of electric resistance loss

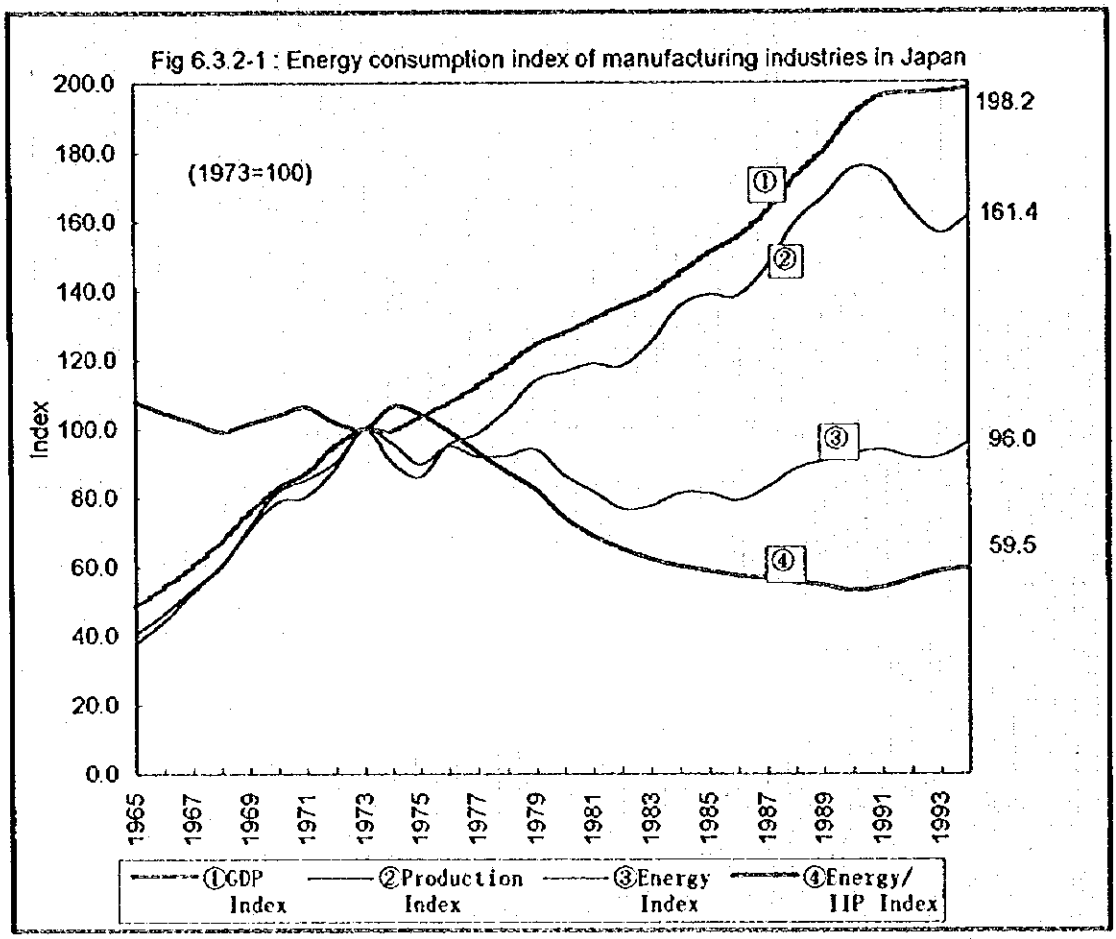
⑦Improvement of conversion efficiency from electricity to power

1) Governmental policy option

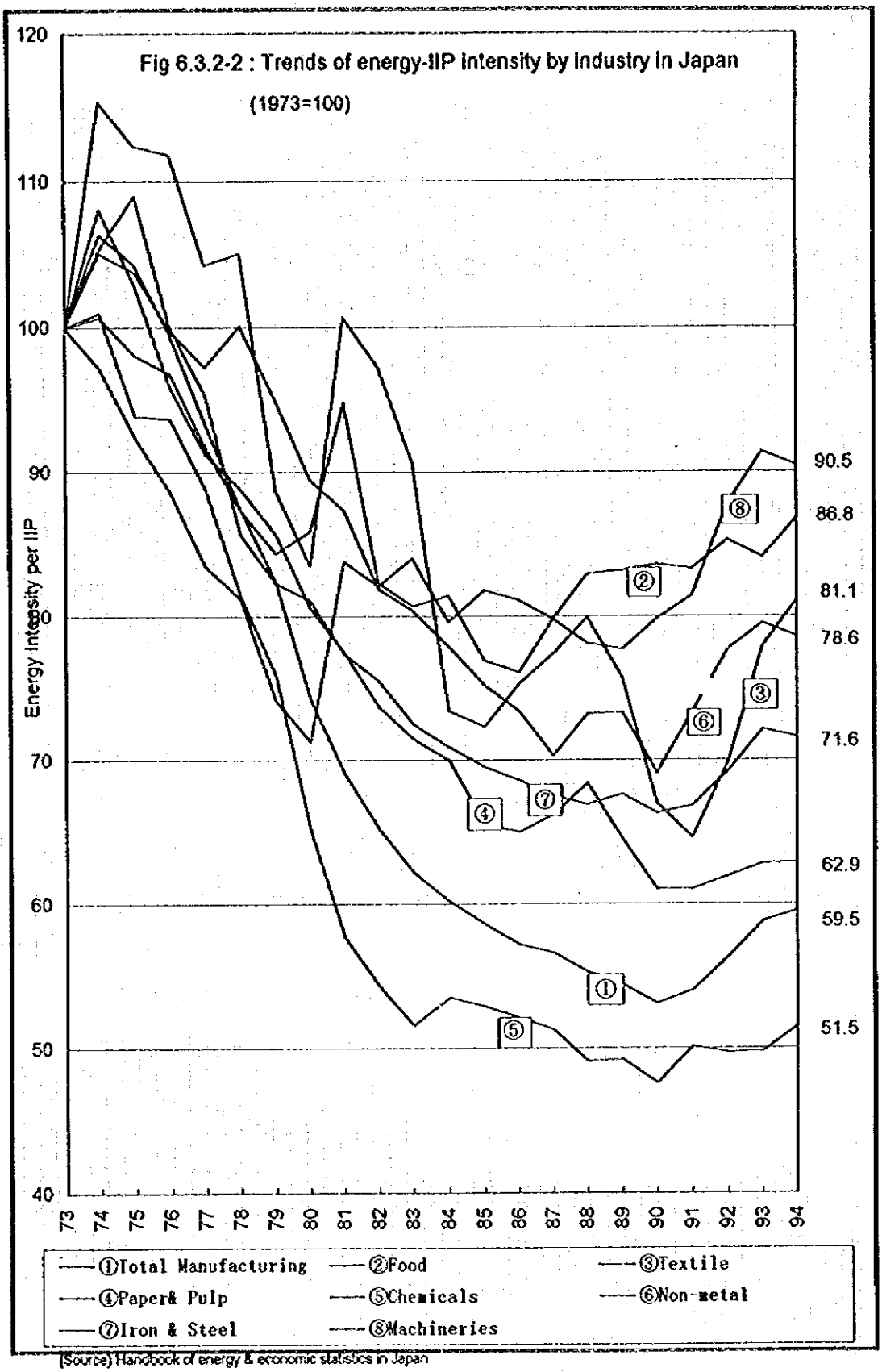
(a) Industrial sector

As illustrated in Fig 6.3.2-1, about 40% of energy conservation was achieved in Japan in the total manufacturing industries in terms of energy/IIP index during 1973 and 1994, the sector-wise breakdown of which is shown in Fig 6.3.2-2.(Note)IIP: Index of Industrial Product)

Fig 6.3.2-2 implies that the most potential industrial sectors for energy conservation are so called energy intensive industries like chemicals, paper & pulp, iron & steel and, non-metal products, while the other sectors such as textile, food and machinery have relatively small potentials although total energy consumption in each industrial sector is to be taken into account in the evaluation. Energy consumption in these energy intensive sectors shares 66% of the total manufacturing sector in GTA, having the largest potential for energy conservation.



(Source) Handbooks of energy & economic statistics in Japan



(Source) Handbook of energy & economic statistics in Japan

■ Small & medium size industries (≦100 persons)

Small & medium size industries are estimated to have more than a 50% share of energy consumption and a 99.6% share in the number of workshops in the industrial sector in GTA. Table 6.3.2-1 shows the sector-wise number of industrial units and workers in GTA.

Table 6.3.2-1 : Total number of industrial units and workers in GTA (1994)

Industrial Code Sector	Workshop Size (No of Workers)				Total Number Unit	Total Number Worker
	Small	Medium		Large		
	1-10	11-50	51-100	100<		
31 Food	6,703	182	21	20	6,926	42,399
32 Textile	24,195	527	21	36	24,779	99,400
33 Wood	4,063	49	0	2	4,114	9,920
34 Paper	2,229	171	13	23	2,436	17,899
35 Chemicals	2,623	247	33	48	2,951	42,311
36 Nonmetal	1,454	218	19	29	1,720	24,748
37 Iron	887	60	3	13	963	11,121
38 Machinery	18,307	683	72	105	19,167	120,490
39 Others	7,795	126	6	7	7,934	23,512
(Total)	68,256	2,263	188	283	70,990	391,800

(Source) AQCC (INTR632E)

(b) General service and household sector

■ Commercial sector

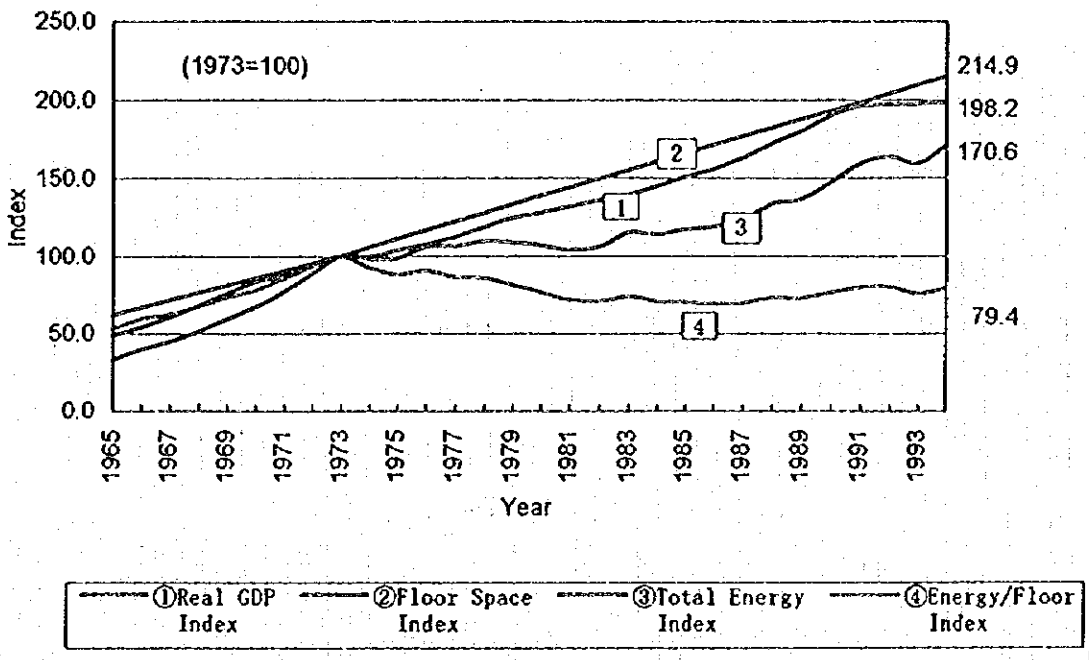
Fig 6.3.2-3 illustrates the energy consuming trend per floor space, which shows about 20% of energy conservation from 1973 to 1994. Although an energy consuming share of the commercial sector is 6% in our current projection, it is estimated to increase to an almost equal share with that of the household sector (27% in 1994) according to the long term forecast in line with the developed countries. Consequently, early introduction of the government guidelines for encouraging energy conservation by using heat insulating architect structures and energy efficient appliances among others are suggested to be incorporated in business licenses of this sector.

■ Household sector

The household sector shares 27% of the total energy consumption and ranks the 2nd among the sectors in GTA, which follows 47% share of the 1st ranked industrial sector.

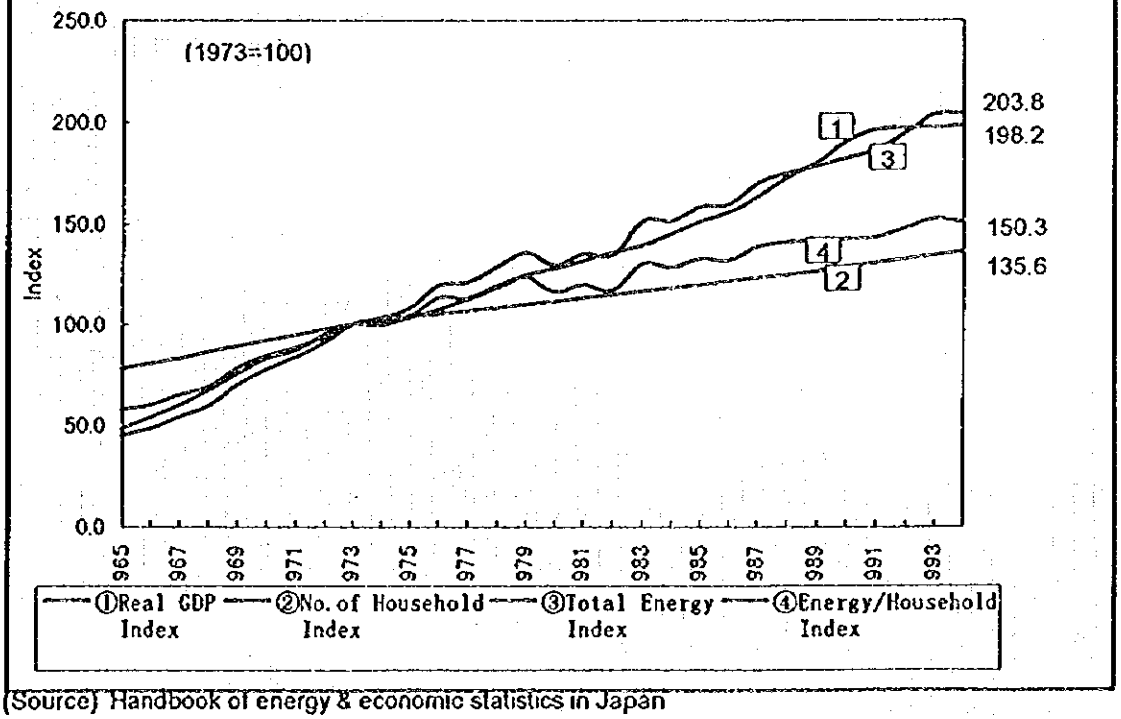
Figure 6.3.2-4 illustrates the energy consuming trend per unit of household, which shows a mild

Fig 6.3.2-3 : Energy consumption index of commercial sector in Japan



(Source) Handbook of energy & economic statistics in Japan

Fig 6.3.2-4 : Energy consumption index of household sector in Japan



(Source) Handbook of energy & economic statistics in Japan

upward trend indicating a tendency different from the other sectors and reflecting improvement of quality of daily life. However, it is observed that the elasticity of energy consumption per unit of household to the real GDP index has been higher than 1.0 since 1973, meaning that the same guidelines with the case of commercial sectors will also be effective in this sector.

2) Implementation procedures for energy conservation

(a) Industrial sector

Energy conservation methods for the industrial sector have many standards and common features, while there is a wide variety of the industrial types among them.

Table 6.3.2-2 illustrates typical examples of the energy intensive industries, while Table 6.3.2-3 illustrates examples for small & medium size industries with detailed explanation of each item in the separate instruction books which has been publicized. MOT is recommended to collect, compile and distribute under its strong leadership these case studies in order to supply the industrial sector reference data for energy conservation methods. Because there are many other instruction books published in the world, it is believed unnecessary to mention anything in this report except one example of a brick manufacturing company in Japan, since many similar brick industries are located in the suburbs of GTA, which have long time been regarded as one of the major emission sources of pollutants.

■ Energy consumption in the brick manufacturing industries in Iran and Japan

□ Process and utilities :

The typical process of this industry is shown in Fig 6.3.2-5, and utility consumption in the case of Iran is shown in Table 6.3.2-4.

□ Comparison between typical manufacturers in Iran and Japan

Item	Unit	Iran	Japan
Production	ton/year	7,000	30,000
Raw material	ton/ton-product	1.04	1.01-1.05
Fuel	1,000kcal/ton-product	790	300-500
Electricity	kwh/month*ton-product	10.5	3-7
Worker	number/month*ton-product	30	5-8

Table 6.3.2-2 : Energy conservation (EC) procedures of energy intensive industries

Sector (EC/IIP target)	Energy conservation procedures	Typical examples
Iron & steel (20%)	①Improvement of operation,②Recovery of waste energy, ③Improvement of process, ④Improvement of energy efficiency	①High temp continuos casting,②Dry type back pressure recovery, ③Dry type cokes extingusher
Petrochemicals (30%)	①Use of high efficiency equipment,②Improvement of process ③Improvement of operation,④Recovery of waste heat	①Naphtha cracking of high efficiency,②High efficiency compressor, ③Gas turbine
Cement (20%)	①Conversion to NSP,②Improvement of mills for materials and finishing,③Recovery of waste heat,④Proper fuel combustion	①SP & NSP kilns, ②Vertical type mills for materials and finishing, ③Power generation by waste heat of low & middle temp
Paper & pulp (30%)	①Change to continuous process,②Waste heat recovery, ③Change to efficient process,④Recycle paper use	①Continuous & counter flow digester,②Pulp washing of high efficiency,③Size pressing of high efficiency
Dyeing (25%)	①Low bath ratio dyeing,②Excellent maintenance,③Recovery of waste heat of warm water,④Improvement of processing conditions	①Jet flow type dyeing,②Counter flow washing,③Grate conveyor type drying
Sheet glass (30%)	①Heat insulation,②Improvement of kiln insulation,③Improvement of heat accumulation efficiency, ④Recovery of waste heat	①Waste heat boiler,②Heat insulated melting furnace
Refinery (10%)	①Recovery of waste heat,②Proper air ratio,③Air preheater maintenance,④Use of high efficiency rotating machines	①Optimization system for operation,②Co-generation, ③Waste gas holder,④Waste heat boiler
Thermal Power (5%)	①Proper air ratio,②Lower flue gas temp,③More heat insulation of boiler,④Air preheater maintenance	①Variable pressure once-through boiler,②Co-generation, ③Combined cycle,④High efficiency turbine blades

Table6.3.2-3(1) : List of Energy Conservation Appliances (Common for all Industrial Sectors)

Page	Item No.	Application	Basic Theory	Energy Conservation Effect
1	MI-ME-F01	Shaft power reduction for blower	Control by dampa,vane,variable pitch,rotating speed	Reduction of power by 10-15%
2	MI-ME-F02	Moisture removal by refrigeration	Removal of moisture in drain by cooling air	Reduction of power by 10-15% compared to other methods
3	MI-ME-P01	Rotation control pump	Volume flow control by rotation control of pump	Reduction of power by 20-50% compared to control vanes
4	MI-ME-D01	Oil clutch	Variable speed joint by transmiting rotation with oil pressure	Reduction of blower power under low load operation
5	MI-ME-D02	Torque converter	Variable speed control for power shaft rotation by oil volume control	Reduction of blower power under low load operation
6	MI-ME-C01	Low NOx burner with 3 elements	Atomising water in amount of 5-10% of fuel volume	Fuel reduction by 3.4-5.1%
7	MI-ME-C02	Ultrasonic burner	Promotion for air/fuel diffusion mixing by ultrasonic	Low NOx emission with low O2 combustion
8	MI-ME-C03	Low O2 burner	Promotion for low O2 combustion	Improvement of boiler efficiency by 2-3%
9	MI-ME-C04	Fludized bed combuster	Combustion in fludized bed	Energy conservation by 100% in case of waste materials
10	MI-ME-C05	Radiant tube burner	Heating outer side of tube by heating inner side of tube by gas combustion	Twice heat efficiency compared to conventional burner
11	MI-ME-W01	Waste heat boiler	Heat recovery of flue gas from various furnace and kiln	Energy conservation by 100% in waste heat recovery
12	MI-ME-W02	Waste materials combustion boiler	Combustion of waste materials as wood chip and city garbage	Energy conservation by 100% in waste heat recovery
13	MI-ME-W03	Hot water drum by compressed air heat	Hot water generation by adiabatic compression heat	Energy conservation by 100%
14	MI-ME-W04	Hot water drum by waste materials heat	Hot water heated by heat medium heated by waste heat	Reduction of Low temp corrosion by heat medium of constant temp.
15	MI-ME-H01	Heating equipment by direct steam injection	Heating by direct steam injection into water and/or solution	Energy conservation by 10-15% compared to indirect heating system
16	MI-ME-H02	Heat exchanger to recover low temp heat source	Heat exchanger to recover heat upto temp below acid dew point	Energy conservation by 3-5%
17	MI-ME-H03	Ventilation fan with heat exchanger	Heat exchange with inlet and outlet air	Eenergy conservation by 30-40%
18	MI-ME-H04	Air preheater	Air preheating by flue gas of boiler,etc	Energy conservation by 5-10%
19	MI-ME-H05	Ptate type heat exchanger	Heat exchanger with multilayer heat exchanger plates	Appropriate for heat recovery from low temp heat source
20	MI-ME-H06	Heat pipe type heat exchanger	Heat exchanger with heat pipe	Heat recovery from latent heat source
21	MI-ME-H07	Counter flow rotating type heat exchanger	Heat exchanger to recover waste heat	Reduction of 10% fuel at heat recovery rate of 80%
22	MI-ME-H08	All type of heat exchanger	Heat exchanger for sensible & latent heat recovery with damping element	Recovery by 70-75% of total sensible/latent heat
23	MI-ME-H09	Multi flash type evaporating unit	Equipment to enabe flashing in multi-room chamber	Heat recovery from hot water including scale and corrosive components
24	MI-ME-B01	Small size boiler with high thermal efficiency	Boiler with special fins on convective heat transfer tube	Improvement by 2-5% of thermal efficiency
25	MI-ME-B02	Tight closed damper	High sealing type damper less than 1% fluid leakage	Reduction of holding heat or power loss due to less leakage
26	MI-ME-B03	Automatic damper control unit in flue gas duct	Automatic control damper sequential to start/stop of boiler	Reduction of 50-70 liter/hour in case of 30t/h boiler
27	MI-ME-B04	Automatic recovery unit for steam drain	Automatic feed of recovered drain to boiler	Reduction of 200 liter/hour of fuel oil in case of 30t/h boiler
28	MI-ME-B05	Recovery unit for high pressured drain	Automatic feed of recovered high pressured drain to boiler	Improvement by 10-15% of thermal efficiency of boiler
29	MI-ME-B06	Continuous blow unit of boiler	Continuous small quantity blow of boiler water	Reduction of fuel by 0.8-1.0%
30	MI-ME-B07	Steam accumulator	Steam storage accumulator for damping steam demand variation	Improvement by 4-5% of efficiency for boiler under frequent load change
31	MI-ME-B08	Heat transfer promotor	Heat transfer promotor to be injected into smoke tube of boiler	Reduction of fuel by 3-10%
32	MI-ME-B09	Steam superheater by waste heat	Superheating wet steam by flue gas of small size boiler	Improvement of thermal efficiency by 50-100C superheated steam
33	MI-ME-S01	Steam ejector	Pressure up of low pressure steam by converting steam energy to pressure	Effective use of middle pressure steam converted from low pressure
34	MI-ME-S02	Internal tracing	Heating method by placing internal trace tube in transfer line	50% of steam consumption compared to outer tracing
35	MI-ME-S03	Steam trap	Equipment to take out drain in steam line	Energy conservation depending on steam cost
36	MI-ME-S04	Temperature regulating trap	Trap enabling drain temperture control steam trace	Reduction by 20% of trace steam
37	MI-ME-S05	Pressure reducing valve with steam trap	Pressure reducing valve combined with steam trap	The same effect with steam trap
38	MI-ME-S06	Room heating equipment by hot water	Room heater by hot water	Energy conservation by 20% compared to steam heating
39	MI-ME-I01	Heat insulation materials	To prevent heat dispersion from high temp portion	Reduction of heat dispersion by 20-50% depending on thickness

Table 6.3.2-3(2) : List of energy conservation appliances (common for allindustrial sectors)

Page	Item No.	Application	Basic Theory	Energy Conservation Effect
40	MI-ME-I02	Combined unit of heat generation and insulation	Furnace wall materials combined heat generating unit with insulation	Energy conservation by 30% due to high heat insulation
41	MI-ME-I03	Heat insulation cover	Cover with heat insulation inner lining for steam trap	Reduction of fuel depending on steam cost
42	MI-ME-I04	Compound matrials for heat insulation	Conpound materials of alumina with ceramic fiber	High heat insulation and 40-60% weight of insulating fire brick
43	MI-ME-I05	Heat insulating materials of ceramic fiber	Fine fibers made by aluminum oxide and silicon oxide	Light weight, and high heat insulation without drying treatment
44	MI-ME-G01	Flue gas analyzer	Automatic continuous analysis for flue gas composition	Excess air control for low O2 burner
45	MI-ME-G02	O2 analizer in flue gas	Automatic continuous O2 analysis in flue gas	Excess air control for low O2 burner
46	MI-ME-G03	CO nalyzer in flue gas	Automatic continuous CO analysis in flue gas	Monitoring instrument for effective combustion control
47	MI-ME-G04	Heat flow meter	Instrument to measure heat dispersion from various equipment	Measuring optimum thicknes of heat insulating materials
48	MI-ME-G05	O2 controller	Automatic control of exess air by O2 controller	Reduction of several % of fuel and 20-30% of draft fan power
49	MI-ME-G06	Automatic circulation control valve for pump	Automatic by-pass control for preventing centrifugal pump from overheating	Reduction by 5% of driving power of pump at maximum discharge press.
50	MI-ME-E01	Co-generation unit	Flue gas heat recovering unit from engine electric power generator	Heat recovery of 40-50%
51	MI-ME-E02	Leading power phase condenser	Energy conservation due to improvement of power factor	Improvement of lagging power factor
52	MI-ME-E03	Inverter for controlling alternative current motor	Variable speed change of motor by frequency and voltage control	Energy conservation by 10% at low load operation
53	MI-ME-E04	Lighting control equipment	Variable setting of lighting by 20-100% range	Energy conservation by 40-50% due to constant illumination
54	MI-ME-E05	Flourescent lamp of ball type	Flourescent lamp manufactured in the same shape of ball lamp	Energy conservation by 35% with long life compared to ball lamp
55	MI-ME-X01	Spherical floath g materials	To cover liquid surface by floating on the surface	Reducton by 50% of heat dispersion from liquid surface
56	MI-ME-X02	Multi-layer glae,. panel	Insert air zone beween two glass panel	Reduction of overall heat transfer coefficient by 50% compared to single
57	MI-ME-X03	Glass for heat absorption and/or reflection	Glass faintly coated by titanium or tin	Reduction of air conditioning power by 30% by preventing heat flow
58	MI-ME-X04	Liquid intake equipment	Liquid intaking from liquid surface of tank	Intaking surface liquid 3-30C higher than bottom temperature
59	MI-ME-X05	Solar heater wit. vaccum glass tube	Heater with heat pennel enclosed in vaccum tube	Hot water of 70-80C due to high thermal conversion efficiency
60	MI-ME-X06	Methane biomass unit	Methane production from waste liquid containning orgaic materials	Methane generation of 0.2-18m3 out of waste liquid of 1m3
61	MI-ME-X07	Paint drying and baking unit by inert gas	Paint drying and balong by combustion heat of organic solvent in paint	Reduction of fuel by 70% compared to fresh air dilution
62	MI-ME-X08	Agitator by vibration	Agitation by low frequency vibration	Electric power reduction by 80% compared to rotating type
63	MI-ME-X09	Cleaning unit with vibration	Cleaning by low frequency vibration	Shorter time and better cleaning compared to ultrasonic cleaning
64	MI-OM-F01	Compressor with lower discharge pressure	Discharge pressure to meet with user's requirement	Energy conservation by 5-10% depending on lower pressure requirement
65	MI-OM-F02	Operating efficiency improvement of compressor	Operation of compressor to meet user's requirement and working hour	Energy conservation by 40% by some factories
66	MI-OM-P01	Pump impeller cutting	Impeller cutting in case of pump with allowance in discharge pressure	Energy conservation by 5-10% compared to prior cutting
67	MI-OM-S01	Back oressure change of of back pressure turbine	Change of outlet steam pressure of turbine	Effective use of outlet steam by adjusting turbine output power

Fig 6.3.2-5 : Fire clay brick manufacturing flow sheet

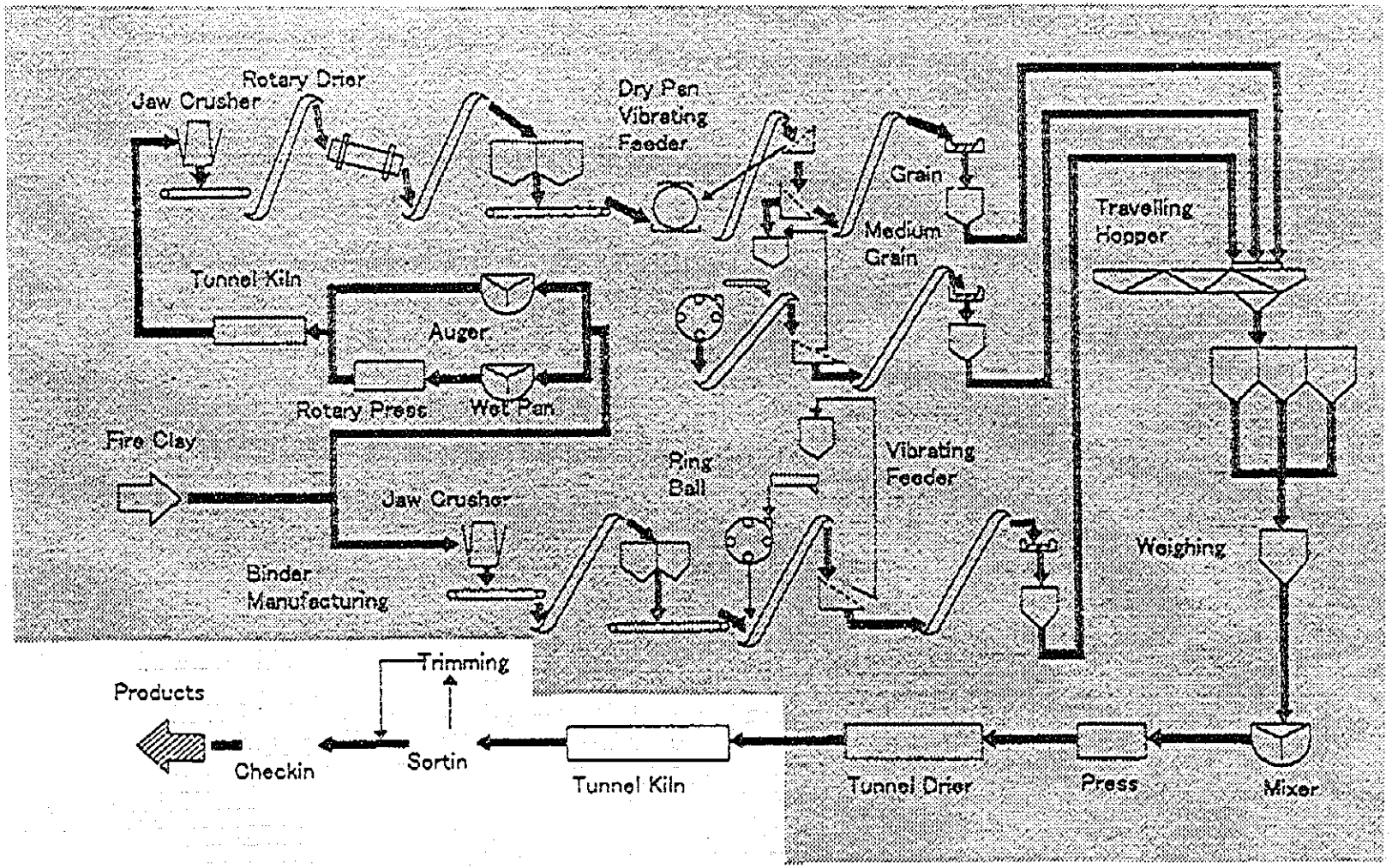


Table 6.3.2-4 : Profit and loss of brick factory (7,000 tin/year)

	Item	Unit	Total amount (10^6 Rs)	Remarks
1	Sales amount	33,000Rs/ton	231	7,000ton/year
	Raw material (Soil)	6,000Rs/ton	44	Unit consumption 1.04
	Naturaal gas	32Rs/m3	19	80m3/ton, 582,400m3/year
	Electricity	55Rs/kwh	4	10.5kwh/ton, 76,440kwh
	Labour cost	700,000Rs/month/person	124	17,000Rs/ton, 225 man-month/year
2	(Variable cost)		191	
	Depreciation			No depreciation in this factory in P/L calculation
	Maintenance cost		36	5,000Rs/ton
3	(Fixed cost)		36	
5	(Total cost)		227	
6	(Total profit)		4	

(Note) (1) Man^month estimation :
- 15 persons for 6 months (March 1-August 31)= 90
- 30 persons for 4.5 months (April 1-August 31)=135, (Total) 225

(2) Total investment of this factory is projected as 3 billion Rs in this factory

(Source) One of the brick manufacturing companies interviewed

In the process comparison from the energy conservation standpoints based on the above table and Fig 6.3.2-5, most of the unit operations indicated by dark color in Fig 6.3.2-5 are conducted manually with use of solar energy for drying units where applicable in Iran, and quality control of the products is quite different so that comparison between the two countries is almost meaningless although energy consumption per ton of product in Iran is about 2 times of that in Japan in an average.

It is, therefore, believed that there are much potentials for improving energy consumption as well as quality of products in the brick manufacturing industries in Iran.

(b) General service & household

Rapid expansion of population combined with a high growth rate of natural gas and electric power use in parallel with penetration of gas and electric appliances for cooking, lighting, hot water and air conditioning in GTA are spotlighted in this section.

Heating and combustion characteristics of such energy sources are undoubtedly better than others from view points of accessibility, cleanliness, end-use thermal efficiency and pollutant reduction. Since this sector shares 33% of the total energy consumption of GTA in 1994, impact of energy conservation in this sector is substantial.

Fig 6.3.2-6 shows improvement in energy efficiency of home electric appliances which indicates that more than 40% energy conservation can be expected for an air conditioner and a color TV and about 65% for a refrigerator compared to the conditions in 1973. The similar argument applies to other types of gas and electric appliances as evidenced in many published literatures. Powerful administrative guidelines for introducing an energy conservating type of appliances as well as standardization of them are therefore recommended for implementation in well advance of explosive popularization of these appliances in GTA.

Furthermore, a large volume of natural gas escapes from pipelines due to poor maintenance, so that enforcement of measures preventing such leakage is also believed to be another effective method for energy conservation in addition to safety issues.

3) Demand side management for energy conservation

Described below is so called NEGAWATT or DSM (Demand-Side Management), which was

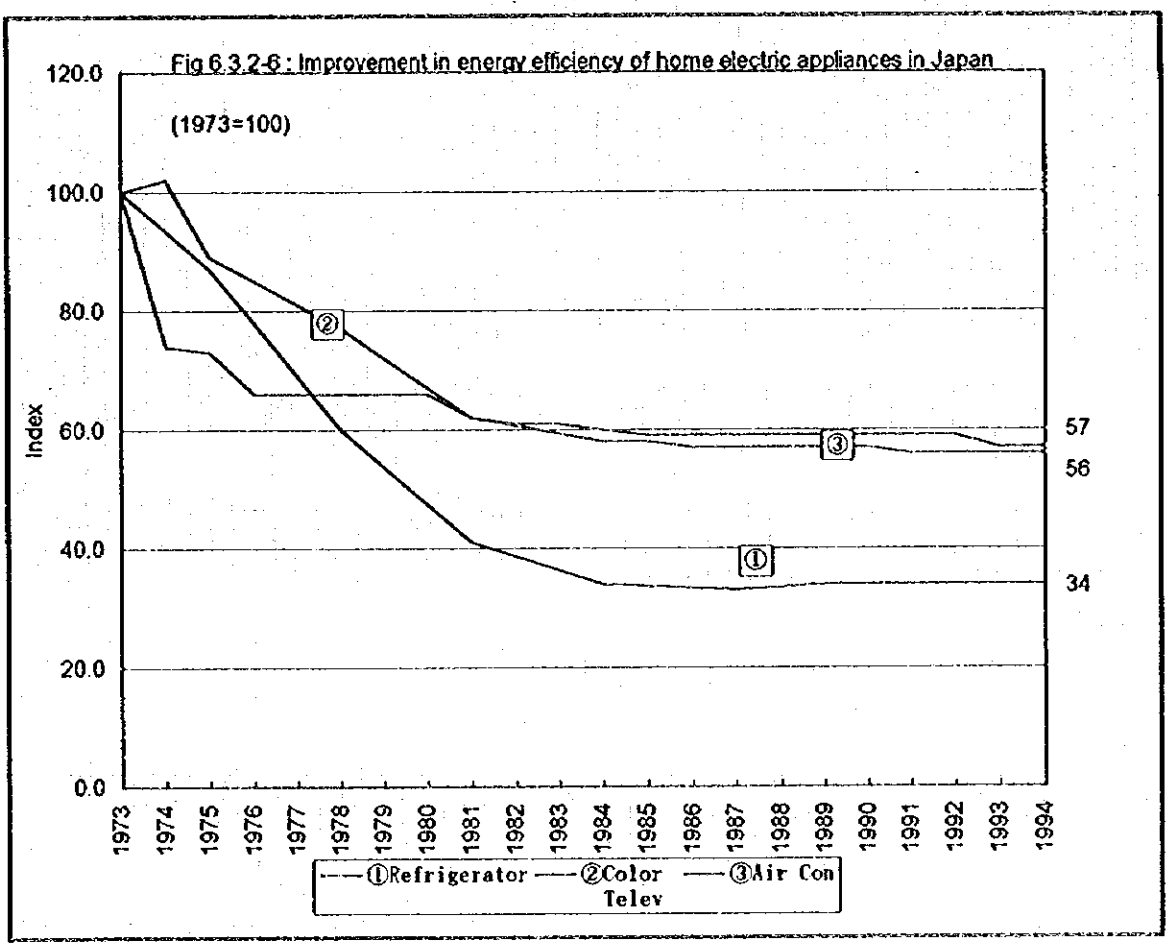


Fig 6.3.2-6 : Improvement in energy efficiency of home electric appliances in Japan
(1973=100)
Index
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
①
②
③
57
56
34
①Refrigerator
②Color Telev
③Air Con

successfully conducted in California in USA as a tool to reduce energy consumption in the Industrial and General Service & Household sectors.

Fig 6.3.2-7 shows an example of an energy conservation chart for electric power consumption, which can be applied to any other sources of energy. The stepwise numbers in the chart illustrate energy conservation measures, and the width and height of each step indicate energy consumption quantity and its cost. The chart is arranged to locate less expensive energy conservation procedures on the left side and pile up each step to indicate the expense and effects of DSM.

The energy conservation quantity and its expenses are calculated on the assumption of capital recovery years and a discount rate in evaluating the respective energy conservation measure and technology.

As shown in Fig 6.3.2-7, about 50% of current electricity consumption can be saved at the cost lower than the current electricity charge (8.07¢/kwh), pointing to immense potentiality for energy conservation by means of DSM.

Fig 6.3.2-8 shows real effects of DSM in California compared with the others, clearly demonstrating that the electricity consumption in 1992 is almost on the same level with 1979 in California due to DSM, while about 19% more in the other states.

(2) Pollution control procedures

Contribution of pollution control to the reduction of air pollutants is to be evaluated separately from the reduction contributed by energy conservation. The major air pollution control measures that MOF has conducted are as follows:

- Fuel replacement with natural gas
- Use of low sulfur petroleum and electricity
- Relocation of hazardous work units

The fundamental technologies for air pollution control except energy conservation are widely known. Air pollution control measures in this report are prepared in the form of single or combined methods using the following technologies.

The application procedures of these technologies are not mentioned in this report, since it is

Fig 6.3.2-7 : Energy conservation chart by DSM

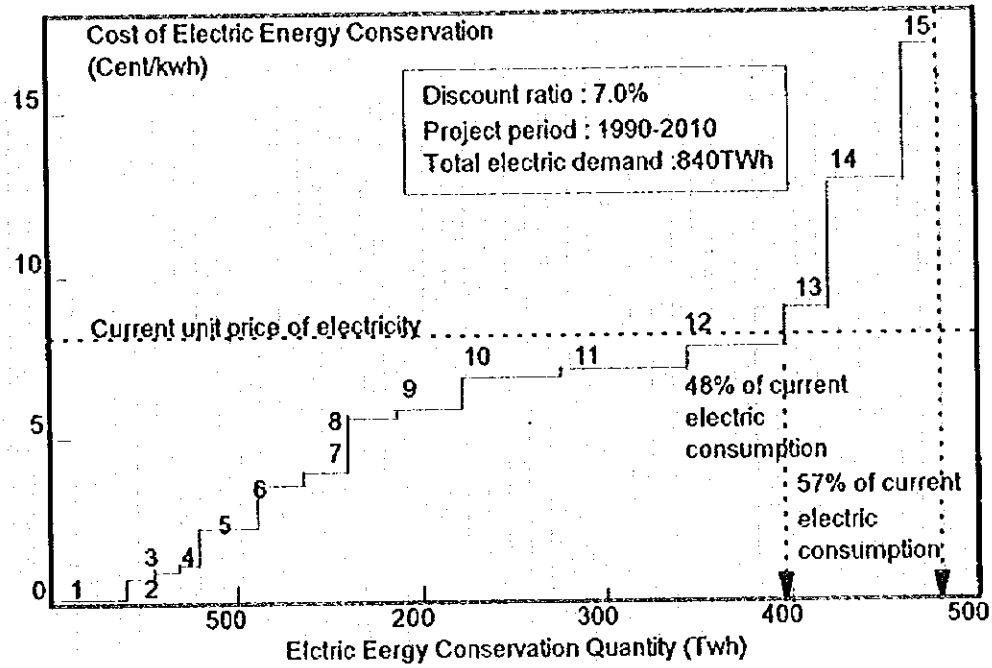
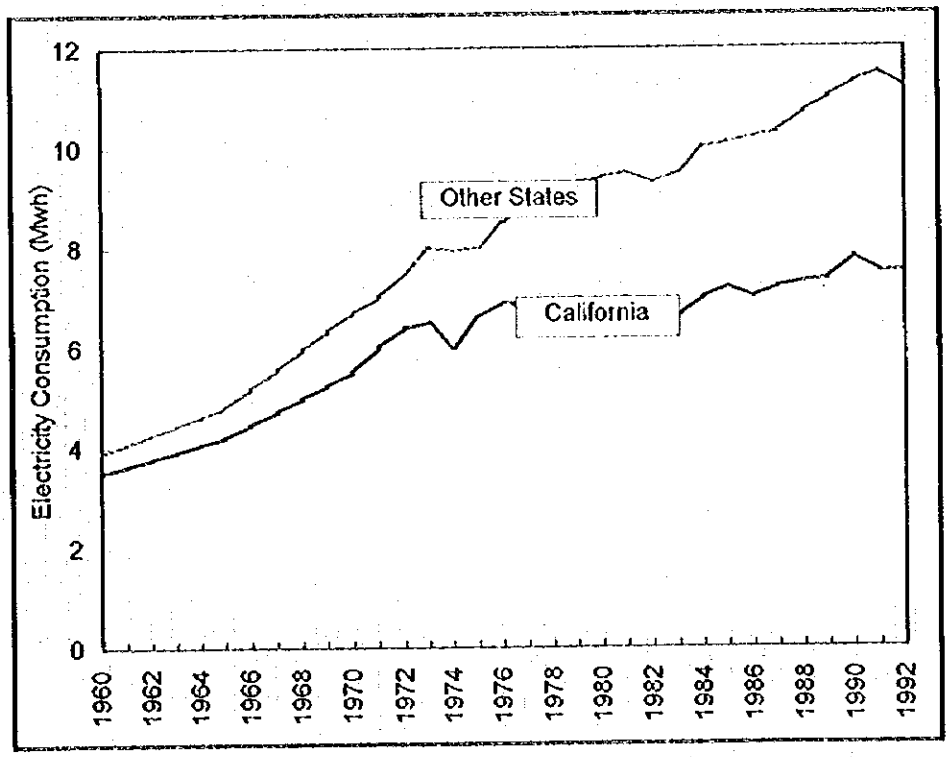


Fig 6.3.2-8 : Energy consumption per capita in California and the other states



self-evident and relevant information is widely available in the world.

①Sox : - Reduction of sulfur content in fuels (Hydrodesulfurization)(HDS)
- Flue gas desulfurization (FGD)
- Gypsum recovery process
- Ammonium sulfate recovery process
- Sodium sulfite recovery process
- Simultaneous removal with NOx (by activated carbon)
- Fuel replacement with low sulfur fuels like natural gas

②NOx: - Combustion modification (CM)
- Low NOx burners (LNB)
- Two stage combustion (TSC)
- Flue gas recirculation (FGR)
- Off-stoichiometric combustion (OSC)
- Flue gas denitrification
- Selective catalytic reduction (SCR)
- Selective noncatalytic reduction (SNR)

③CO : - Perfect combustion

④HC : - Perfect combustion
- Vapor recovery from evaporation sources
- Prevention of natural gas leakage from pipelines

⑤SPM : - Perfect combustion
- Electro-static precipitation
- Cyclone
- Bag filter

1) Industrial sector

(a) Energy intensive sector

Since business units in this sector are generally large and consume a large amount of fossil fuels as exemplified by thermal power plants and refineries of the energy conversion sector, the more direct and effective preventive measures for air pollution control as shown in Table 6.3.2-5

need to be applied. It is also strongly advised to install extensively direct oil desulfurization units at refineries in order to fully exterminate the origin of SOx generation.

Table 6.3.2-5 : Air pollution reduction procedures by energy intensive industries

	Procedures	Thermal power	Refinery	Cement
1	Sox reduction			
1.1	Direct de-Sulfur	(Natural gas)	○	(Natural gas)
1.2	Flue gas de-SOx	(Natural gas)	○	(Natural gas)
2	NOx reduction			
2.1	Flue gas de-NOx	○	○	○
2.2	Combustion Modification			
2.2.1	LNG+TSC+FGR	○	○	○
2.2.2	LNB+FGR	○	○	○
2.2.3	TSC+FGR	○	○	○
2.2.4	LNB+TSC	○	○	○
2.2.5	TSC	○	○	○
2.2.6	LNB	○	○	○
2.2.7	OSC	○	○	○
3	Dust reduction			
3.1	ESP		○	○

(Note) ○ : Equipment to be installed

(b) Small & medium size industries

As shown in Table 6.3.2-1, there are approx.70,000 industrial workshops in GTA, among which, 2,730 units have more than 10 workers. These workshops (>10 workers) are projected to have an energy consumption share of more than 68% in all the manufacturing industries in GTA.

It is possible to collect and accumulate all required data and information regarding fuel combustion systems of these industrial units by means of questionnaires and direct interviews. Based on these specific data (data inventory for environmental control in GTA) , MOT can establish reasonable pollution control measures including relocation of hazardous industries presently located in GTA.

In this sector, the major targets are to be NOx and HC reduction, while SOx can be reduced by use of low sulfur petroleum and natural gas. NOx reduction can be made by means of

combustion modification technologies to be applied intensively to numerous small sized steam boilers and heating furnaces in this sector, and HC reduction can be achieved by strong administrative instruction addressed to emission sources such as petrol stations, painting, cleaning, printing and electric metal coating shops. One of the study conducted by the Tokyo Metropolitan Government is illustrated below.

- Steam boilers of small size (heating area<10m2, heat output>50,000kcal/h)

In Tokyo, low NOx steam boilers are officially recommended with financial incentives principally to reduce NOx emission. Manufacturers of the equipment are licensed if emission of NOx is below the guideline of 60ppm in the case of gas fuel, and 80ppm in the case of liquid fuel under 0% of O2 equivalent basis. Registered manufacturers total 25 in 1996. About 500 tons out of 2200 tons of NOx would have been reduced per year, if all boilers had been replaced. Step-by step replacement is strongly recommended for environmental countermeasures.

2) General Service and Household

There are about 1,500 thousand household units and 300 thousand commercial units in GTA. These numbers suggest that there are no other method to know real energy consumption patterns in this sector except a statistical projection based on the sufficient number of sampling. Thus obtained projection will provide MOT with persuasive grounds to establish an energy conservation program as well as to conduct an energy conservation campaign targeting inhabitants in GTA.

The major items for administrative guidance in this sector are shown below.

- Popularization of low sulfur petroleum fuels and natural gas
- Instruction how to attain full combustion of fuels
- Prevention of natural gas leakages

In this sector, campaigns for energy conservation in the daily life of inhabitants are particularly important, so that MOT will have their full cooperation in energy conservation and pollution control activities. As one of such campaigns, establishment of the following special memorial days is suggested, when brochures describing WHY and HOW TO for energy conservation will be distributed.

- Day of energy conservation and pollution control : one day in a month
- Month of energy conservation and pollution control: one month in a year
- Overall energy inspection and pollution control day: one day in a year, among

the days of energy conservation and pollution control.

(3) Cleaner production technologies

Cleaner production technologies are combination of energy conservation and direct pollution control technologies, which include closed-systematization or conversion of manufacturing processes and proper screening of raw materials unlike most of the end of the pipe countermeasures. The process conversion means the replacement of existing technologies for an environmentally friendlier ones by the catalyst improvement, containment or recirculation of wastes within the process loop, and minimizing the side reactions. A few typical examples in chemical industries are as follows.

1) Conversion of caustic soda process

Triggered by MINAMATA disease in Japan caused by methyl mercury containing effluent discharged by acetylene carbide factory, the public attention was focused to mercury compounds in waste water discharged from caustic soda manufacturing units.

The Japanese governments reacted to this problem and worked out a guideline that practically banned the existing process using mercury electrode and mandated the industry to deploy mercury free alternatives. To comply with such request, the industry expedited the process conversion while proceeding closed systematization of the existing units. However, a first technical difficulty encountered by the industry was poor quality of membrane made of asbestos implemented in the early stage. The plant using such asbestos membrane was also highly energy consuming one and was found cost incompetitive. In accordance, the industry made concerted effort trying to improve the membrane quality which resulted a few years later in the development of energy efficient ion-exchanging type membrane.

2) Improvement of polypropylene process

Catalyst for polymerization has a vital role in this process. Due to the improvement of

catalyst by R & D activities, the manufacturers have succeeded in developing catalyst activities which enables elimination of de-ashing, atactic polymer removal and pelletizing sections of process, resulting in remarkable reduction of energy consumption and waste by-products as well as improvement of production cost and product quality.

3) Improvement of stylene monomer process

This process traditionally required a large amount of high temperature steam consumption in its dehydration of ethylbenzene and entailed the condensed waste water treatment. However, the dehydration section has been greatly improved such that the reaction can take place at a lower temperature and with less steam consumption. The process conversion thus resulted in a significant energy saving as well. Also noteworthy is that the sulfur containing polymerization inhibitor could be dispensed with.

4) Improvement of vinyl chloride monomer process

The oxychlorination section in this process was essentially air oxidation that led to a large amount of exhaust gas treatment but by changing air to oxygen, the exhaust gas was significantly reduced. The exhaust gas contains such components as EDC, ethylene, and a large volume of nitrogen gas.

6.3.3 Management for stationary emission control

The pollution control program should be designed comprehensive to attain the target environmental quality standard which is to be accomplished by the pollution control administration and financial management in each community as shown in Fig 6.3.3-1 & 6.3.3-2. The basic pollution control policy is first to be established by the central government, which subsequently is to instruct each local government to prepare and execute the pollution control programs for its own area. In this sense, MOT is principally responsible for environmental management in GTA.

The governmental management of air pollution control should include the following functions and systems:

- Administration management
  - ① Legislation
  - ② Pollution control agreement
  - ③ Monitoring and assessment systems
  - ④ Organization for management
  - ⑤ Education and qualification systems
  - ⑥ Data base for energy conservation and pollution control

- Financial management
  - ① Financial incentives for pollution control
  - ② Governmental expenditures and private investment
  - ③ Discussion on financial sources

In this report, the key factors of each item above are discussed below, and the general discussions on the environmental management are omitted.

(1) Discussion on administration management

1) Legislation

Although the Clean Air Act was enacted in 1995, no definite emission standards have been established in Iran while the quality standard exists as shown in section 2.2.3. Therefore, in place of the indigenous standards, the standards prepared by WHO have been provisionally applied as

Fig 6.3.3-1 : Flow Chart of Master Plan for Air Pollution Control in GTA

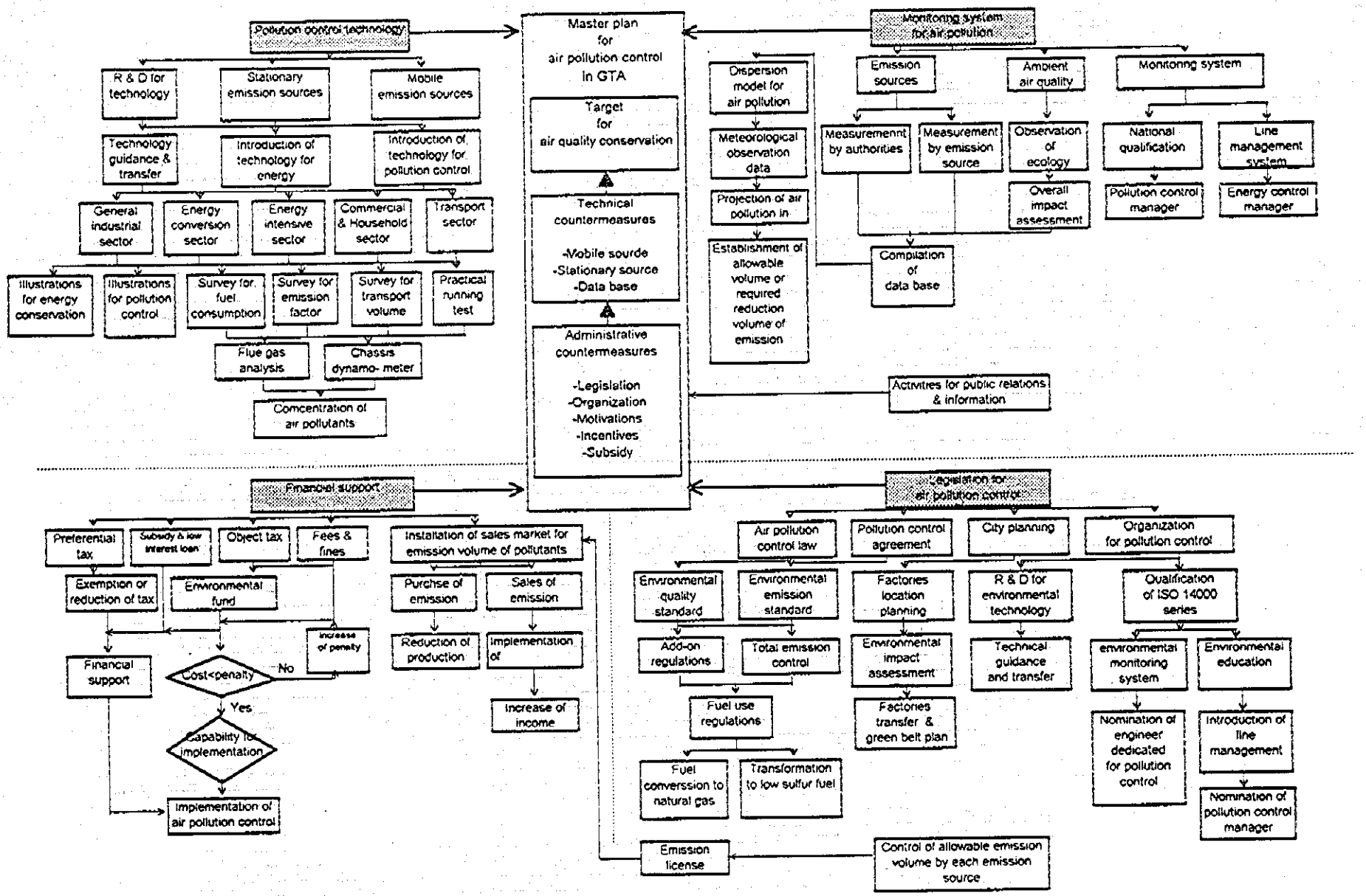
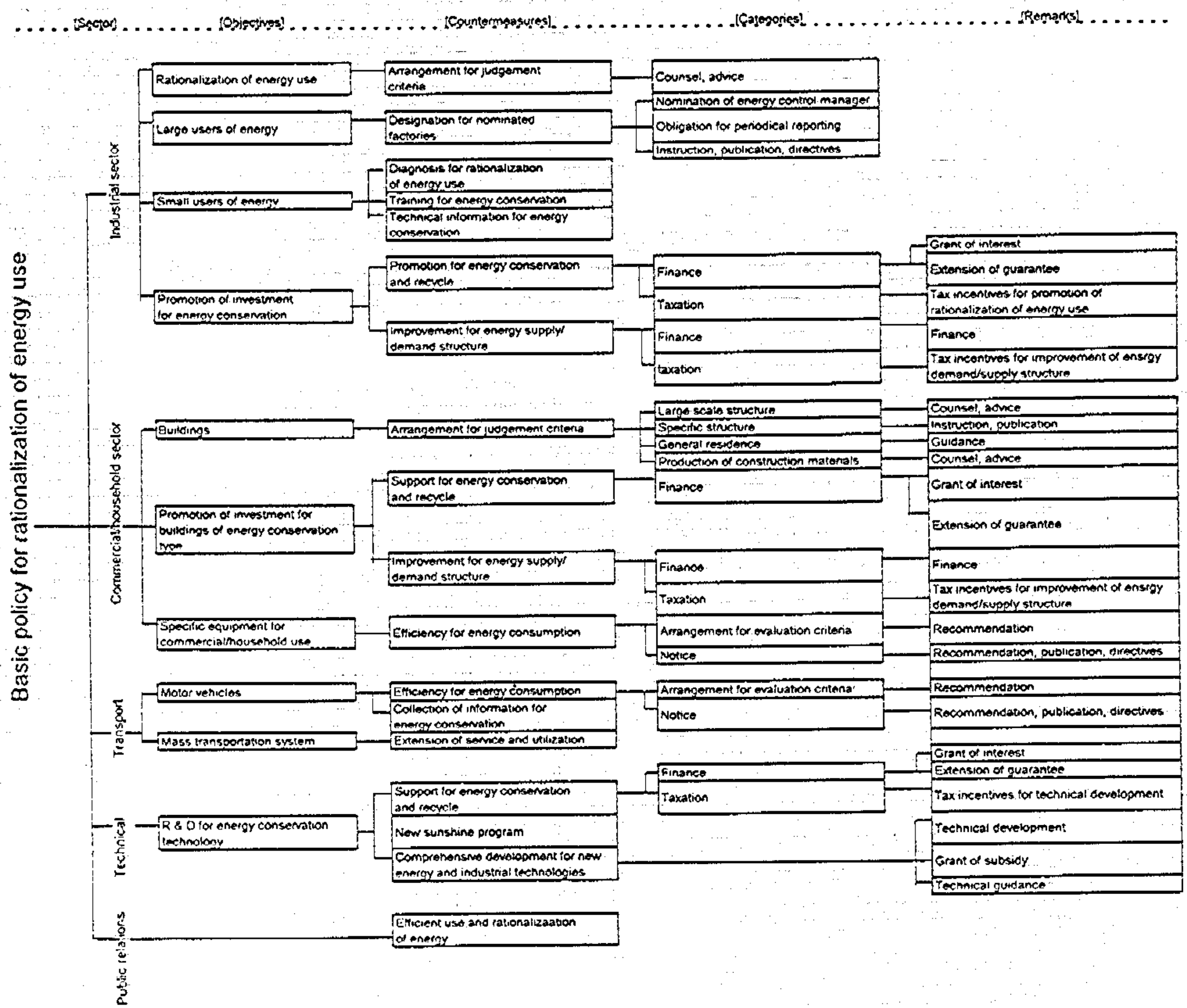


Fig 6.3.3-2 : Typical Energy Conservation System



the accepted standards in GTA. Hopefully, the Iranian standards and the local government regulations will be legislated in the near future, and, at that time, the following discussions are to be considered:

(a) To authorize the local governments to establish emission standards more stringent than those established by the central government (add-on regulation)

It may be necessary for MOT to legislate stringent regulations of its own because the local conditions such as industrial and urban structures, geographical features, weather, water systems, the present level and the estimated future level of environmental pollution may require more stringent standards than the national ones, which will be general standards covering all the country and will not always meet specific local conditions.

(b) Standard for total emission control

This standard is applicable to the area where, because of concentration of factories and other business units, the satisfactory environmental quality level would not be met on the basis of the quality standards which are set forth based on the emission standards applicable to individual facilities. In such areas to be designated by the government, the total emission control should be applied. The total emission control standard is to be introduced in GTA with scientific rationale, since the total reduction approach is by nature the most powerful means to be applied to the most adversely affected area like GTA where emission sources are densely sited.

(c) Fuel regulation

As one of the most effective means for SOx emission control, use of low sulfur petroleum fuel and natural gas are to be made mandatory on certain conditions pursuant to the local regulations of GTA, because urgent reduction of SOx concentration in GTA will be occasionally needed. Accordingly, MOT will be obligated to supply low sulfur fuels as the case may require.

2) Pollution control agreement

This is the agreement between a local government and local enterprises, over which local government has jurisdictions to prevent environmental pollution. Such agreements may not be fully enforceable because a violator of the agreement cannot necessarily be penalized in practice. Each agreement, however, is binding to the parties who are not supposed to violate the agreement. Consequently, such an agreement is nearly as effective as a regulation. The merits of such an agreement are:

(a) The agreement will enable the local government to precisely and effectively enforce pollution control measures suited for geographical and social conditions of the locality.

(b) Because the primary concern of enterprises is construction of their facilities in the most desired locations, it is not desirable for the enterprise to run its facilities without obtaining the agreement of the local people.

3)Environmental monitoring and assessment system

The monitoring activities for pollution control have been expanded step by step, while the environmental impact assessment (EIA) has not yet been practically worked out in GTA. In implementing the rulings by ORSUITO, it is necessary to take steps of EIA to give the rulings the reasonable authority. For the assessment of stationary air pollution in GTA, at least the following data are to be obtained by the government respecting the reasonable number of emission sources:

- Fuel consumption by types
- Concentration of pollutants in flue gas from emission sources

Since the collection of above data is time consuming and needs elaborated works, it is necessary for the government to build a data collection system supported by a legislation. Thus, mobilizing a large number of fuel consumers, the local government can establish a basic data inventory for environmental control with simultaneous effects for propagation and public awareness for environmental control knowledge.

4) Organization for management

"Small but efficient organization" is aimed by management of many organizations in the world so that management will be flexible and harmonious by maintaining close horizontal and vertical cordination and collaboration. In our observation of many cases during our survey works, however, horizontal coordination and collaboration across reporting lines are not adequate both in central and local government organizations.

(a) Small and efficient organization

Under MOT, many organizations are engaged in environmental control activities as listed below.

- ORSUITO (Organization for Relocation and Systematizing Urban Industrial and Trade Occupations)
- AQCC (Air Quality Control Co.)
- TITO (Tehran Transportation and Traffic Organization)
- TTCC (Tehran Traffic Control Co.)
- TCTTS (Tehran Comprehensive Transportation & Traffic Studies)
- TVTIB (Tehran Vehicle Technical Inspection Bureau)

Because these organizations are located in separate buildings far to each other, mutual communication seems insufficient. In our opinion, the number of organizations under the Deputy Mayor related to both urban services and traffic/transportation should be reduced to less than 50% for better communication and cost saving.

Also, it is suggested that the project team for environmental control be established by these organizations consisting of high ranking members for the sake of more active communications. Furthermore, AQCC and ORSUITO be merged in view of their similarity in core activities, since one is for planning, and the other is for implemention for the same objectives.

(b) Communication with the organization of the central government

Many organizations of the central government are also engaged in environmental matters as illustrated below:

- DOE (Department of Environment)

- MOE (Ministry of Energy)
- MOO (Ministry of Oil)
- MOH (Ministry of Health)
- MOI (Ministry of Industry)
- MO (Meteorology Organization)

A steering Committee has been established and is dedicated for our project under the chairman dispatched by DOE in order to promote smooth coordination among the organizations concerned. Although the committee has not functioned as expected, it is advisable to maintain this committee in the future as a project team joined by both the central and local governments in GTA..

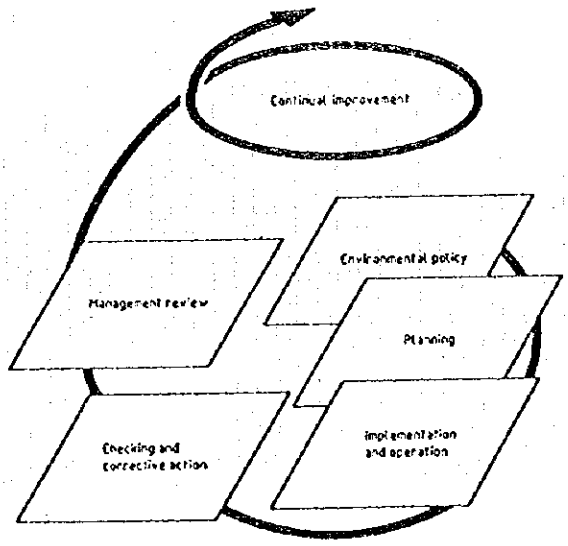
(c) Concept of line management

In stipulating the environmental management system in the legislation, the concept of line management (or line control) has to be followed as distinct from staff management, so that line members who are directly responsible for implementation will be principally responsible for environmental matters.

On the other hand, staff management has ambiguous instruction lines and obscure responsibility. It is seen in many organizations that environment and safety matters are handled by staff organizations instead of line organizations, with the effect that instruction is not always strictly followed.

(d) Qualification of ISO 14000 series

Fig. 6.3.3-3 Basis of approach to ISO 14000



The project team recommends AQCC to take initiatives in the organizations of MOT for qualification under the ISO 14000 series concerning the environmental management activities in GTA.

The introduction of ISO 14001 says that "these international standards covering environmental management are intended to provide organizations with the elements of an effective environmental management system which can be integrated with other management requirements, to assist organizations to achieve environmental and economic goals. These standards, like other international standards, are not intended to be used to create non-tariff trade barriers or to increase or change an organization's legal obligations." The basis of the approach is shown in the Fig 6.3.3-3.

5) Education and qualification system

The full time supervising activities for pollution control in specific factories under the qualification system in accordance with a legislation plays a vital role in the line management. "A Pollution Control Manager" is a very unique system which has been practiced in the industries in Japan and effectively functioned for industrial pollution control. A pollution control manager is to be nominated among line managers, who is legally required to be stationed at the specified factories. His duties are to examine raw materials and fuels in relation to the source of pollutants, to measure the specified items in relation to the causes of pollutants, and to supervise technical matters concerning how to eliminate pollution sources at specified factories. Qualification of a pollution control manager is to be certified either through a national examination or a series of training courses authorized by the central government. Factories in Japan required to appoint a pollution control manager of air quality are as follows:

- All the factories that have facilities which deal with the hazardous substances designated by the law
- Other factories that discharge more than 10,000 m3/hour of gas

6) Database for energy conservation and pollution control

The database for technology of environmental control plays a major role in the pollution control management. In the impression obtained during interviews at many plants in GTA, the

current levels of manufacturing and process technologies of energy conservation and pollution control in Iran appear to be on the similar levels of the OECD countries prior to 1973, the year of the first oil crisis.

It is therefore suggested for MOT to improve such technology level by compiling the database of energy conservation and pollution control under the strong leadership of MOT, and to let fuel consumers use these database in their activities for environmental control. Tables 6.3.2-2 and 3 show one of the examples of this type of databases.

(2) Discussion on financial management

Financial aspects of environmental control for stationary emission sources in GTA are discussed in this section particularly concerning①financial incentives for pollution control, ②governmental expenditure and private investment, and ③suggested financial sources, which are to be required in view of environmental management in the international level.

Estimated expenditures necessary for environmental control in GTA are roughly projected on the assumption that the data available in the OECD countries are applicable with necessary adjustments to conditions of Iran and able to provide some guidelines for this projection.

1) Financial incentives for pollution control

Financial incentives should be assured by national and local legislations in order to ensure effective implementation of pollution control management. The typical financial incentives are described as follows:

①Concessional tax system

②Subsidy and low interest loan

③Tax on polluters

④Fee and fine legislation

⑤Establishment of a market for trading an emission volume of pollutants

(a) Concessional tax system

This system means exemption or reduction of various kinds of taxes and accelerated

depreciation of equipment and facilities for environmental protection.

(b) Subsidy and low interest loan

Subsidy or low interest loan are ways to support introduction of environmental control equipment and facilities in a more positive and straight forward way than tax incentives. As small and medium size industries are financially less capable, it is advisable to encourage them to cooperate among themselves in environmental control activities through joint investment or some other forms when they receive such supports.

(c) Tax on polluters

This system means imposition of tax on polluters in the form of consumption tax of fuels on the basis of "Polluters Pay Principle (PPP)". The proceeds of this tax are set aside for expenditures for pollution control.

(d) Fee and fine legislation

The fee is imposed on pollutants in proportion to the discharged amount even if it is below the allowable emission limit, while the fine is imposed on discharged amounts in excess of the allowable limit. In general, these charges are pooled in the special account and disbursed for pollution control activities. Accordingly, the amount to be levied should be determined in order to enable effective countermeasures and to give enough incentives for reduction of pollutants to enterprises in the region.

(e) Establishment of a market for trading an emission volume of pollutants

The market means the system which allocates the allowable emission volume of pollutants to enterprises and approves the enterprises to sell a margin between the allocated limit and actual emission volume below the limit to other enterprises in the event that such a margin can be attained due to the efforts by the enterprises for reduction of the emission. This system has the same effect with the total emission control regulation, and will motivate technically capable enterprises to reduce pollutants, although it has a demerit because less capable enterprises will prefer to purchase emission volume rather than to make efforts for the reduction.

2) Governmental expenditure & private investment

Concerning stationary emission sources, the study has been conducted focusing on both Small and Medium Size Industries and General Service & Households. Because each unit of these sectors is small and is not very eager to invest in environmental control, the environmental management policies of the government, either central or local, will have great impact on their behaviors. In short, THE GOVERNMENT HAS TO GUIDE THEM.

On the other hand, as large energy intensive industries like the Tehran Cement, big factories in the energy conversion sector like the Tehran Refinery, and the Rey/Besal/Firouz Power Plants in GTA have enough planning and financial capability, their major environmental investments are briefly reviewed.

The real objectives for the estimation of the environmental investments are to know financial expenditures to be required for pollution control in GTA in the order of magnitude from the standpoints of international common requirements.

(a) Roles of government for environmental control

① Environmental budget

The central government has the authority of enacting laws for environmental control, stipulating the target values of pollutants, while the local governments are well acquainted with local environmental conditions and are in a position to enforce regulations applicable to their own areas. As far as environmental regulations are concerned, it is vital for the local governments to be authorized to have stronger power to implement the most effective strategy with a reasonable amount of budget.

② Additional financial source for environmental control

In order to enable the local governments to effectively conduct environmental control, the central government should allocate the additional budget to them in the amount which will be equivalent at least to the opportunity cost of energy conservation assuming that the said opportunity cost be equal to crude oil export revenues.

While in the OECD countries, the benefits of energy conservation are automatically recovered by the initiators through saving of expensive energy costs, it could be recovered in Iran through the governmental subsidy equivalent to the opportunity cost.

According to the international understanding, the best way to control pollution is to take preventive measures by allocating a reasonable amount of budget in advance, like the cases of human diseases. In short, PREVENTION IS CHEAPER THAN COMPENSATION.

(b) Assumptions for financial projection of environmental control activities

The projection is made by means of expenditure ratios of pollution control as illustrated in the following tables as well as the directly collected market prices of such specified equipment and facilities. The ratios are calculated by dividing the total pollution control expenditures covering all sources of pollution such as air and water as well as energy conservation investment that is effective for pollution control by the total expenditures in the sectors concerned or by GNP. The share of air pollution is projected to be 60-70% of the total pollution control expenditures according to the data in Japan.

① Pollution control investment in industrial sectors in Iran

■ General

Table 6.3.3-1 illustrates the ratios of pollution control investment versus total investment or GNP in the private enterprises in the OECD countries in 1974, the year after the first oil crisis in 1973 when the situations are considered to be more or less comparable to the current environmental status in Iran. Since the ratio versus GNP varies from 0.1 to 1.0%, 0.3% is provisionally selected for the case of Iran.

Table 6.3.3-1 : Pollution control investment of private enterprises in OECD countries (1974)

Country	Pollution control investment(A)/total investment	(A)/GNP
Japan	8.0 (%)	1.0 (%)
USA	3.4	0.4
Netherlands	2.7	0.3
Sweden	1.2	0.1
FRG	2.3	0.3
Norway	0.5	0.1

(Source) Japan Environmental Management Association for Industry

Fig 6.3.3-4 shows the trend of annual pollution control investment in the private sector in

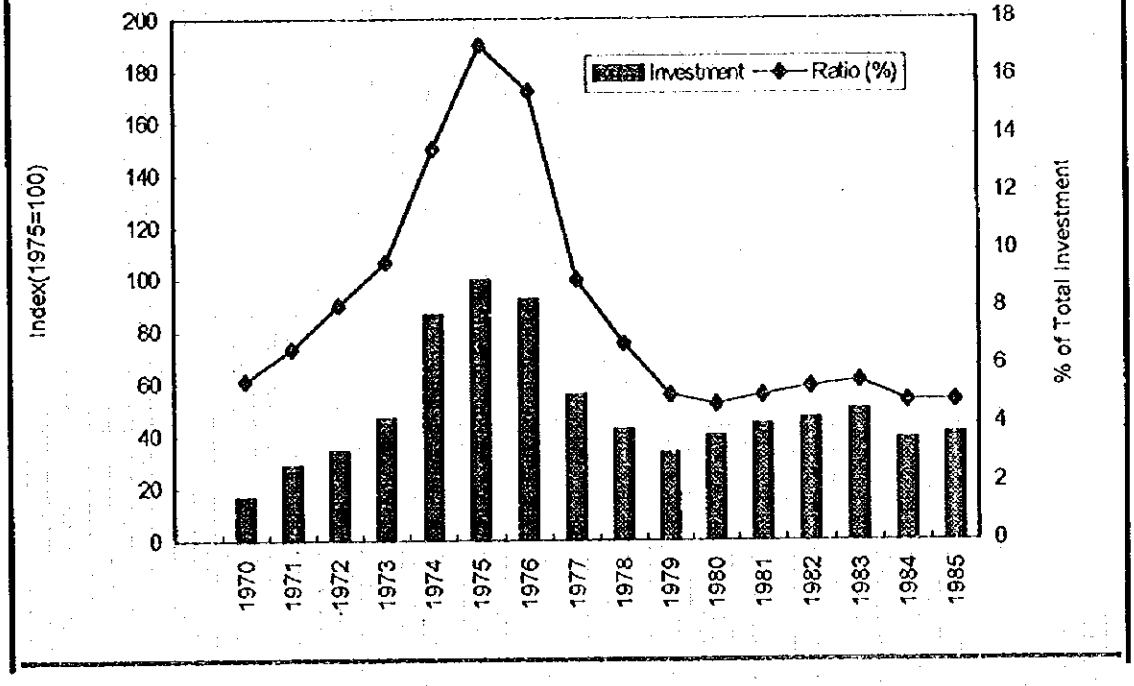
Japan, which indicates sharp increase necessitated by the first oil crisis in 1973.

Table 6.3.3-2 shows the ratios of pollution control investment by industrial sectors, indicating potentiality of pollution control by these sectors, especially by thermal power plants, oil refineries, chemicals, pulp & paper and iron & steel.

Fig 6.3.3-5 shows the ratios of pollution control investment in the energy intensive sectors in Japan, which can be interpreted as follows.

- Environmental investment appears to include energy conservation investment as noticed in the case of thermal power plants which have two humps of investment after the first and second oil shocks.
- The peak investment ratios reflect pollution preventive activities by thermal power plants, refineries, chemicals, iron & steel and non-metals in the decreasing order.
- The average investment ratio is about 5% of the total investment over a long range of years, during which the peak reached 15% in 1975.

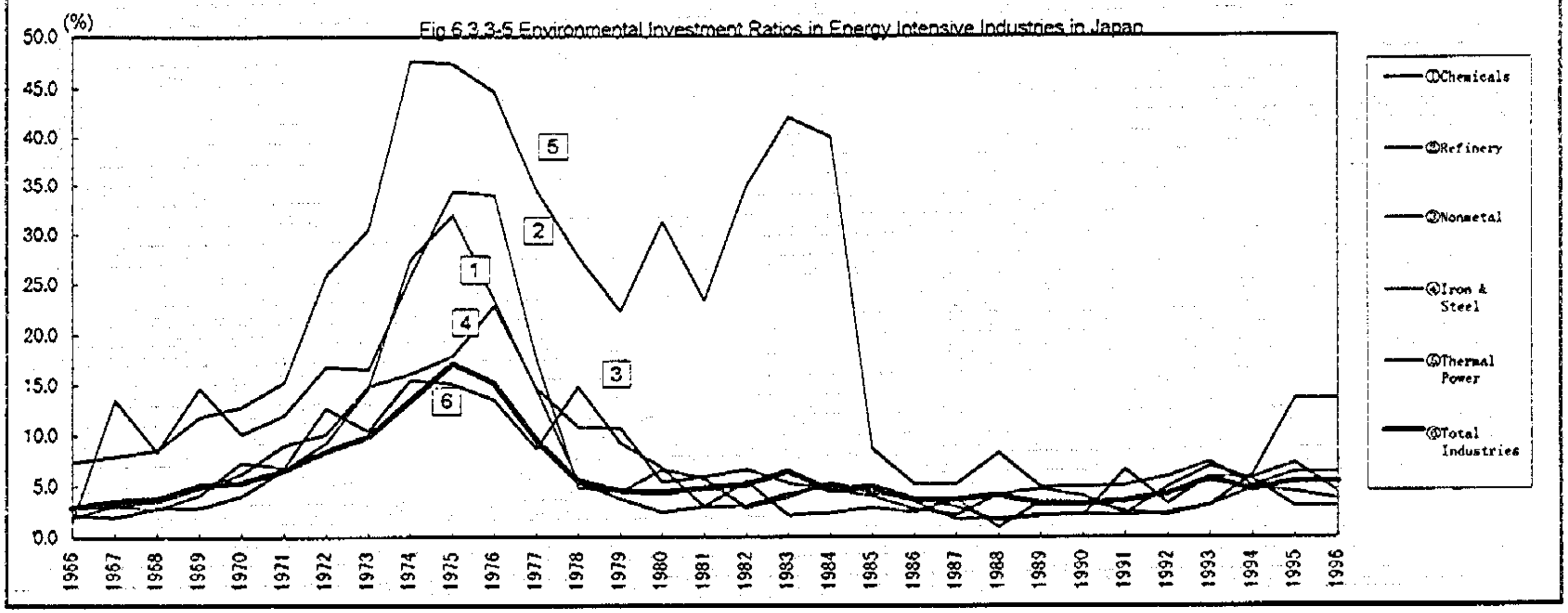
Fig 6.3.3-4 : Annual Trend of Pollution Control Investment by Private Sector in Japan



(Note) All enterprises with equity capital over ¥100 million with mining excluded

(Source) Japan Environmental Management Association for Industry

Fig 6.3.3-5 Environmental Investment Ratios in Energy Intensive Industries in Japan



(Source) MITI (Trends od Anti-pollution Investment in Private Sector)

Table 6.3.3-2 : Pollution control investment by industries in Japan (1975)

Industries	Pollution control investment/sectorwise total investment
Iron & Steel	17 (%)
Oil Refinery	27
Thermal Power	47
Pulp & Paper	24
Chemicals	25
Others	7
Weighted Average	14

(Source) Japan Environmental Management Association for Industry

■ Energy conversion sector

There are three (3) power plants and one (1) refinery in the energy conversion sector in GTA, as shown in Table 6.3.3-3. For air pollution control measures for these very large scale plants, there are well known technologies listed in section 6.3.2.

□ Thermal power plants

Since most of the petroleum fuels such as high sulfur heavy oil have already been replaced by natural gas in the thermal power plants in GTA, reduction of SOx emission in this sector has been nearly achieved, while countermeasures for NOx emission have yet to be taken. Among the available technologies for NOx reduction, SCR (Selective Catalytic Reduction) and CM (Combustion Modification) are selected in this report, since many plants in the world have achieved NOx reduction ratio at around 80% with SCR, while, with the simpler and cheaper method of CM, the achieved NOx reduction ratio has been less than 50% as shown in Table 6.3.3-4.

□ Refinery

The most popular process of HDS (Hydrodesulfurization) is applied for a fraction of heavy oil, gas oil and kerosene as shown in Table 6.3.3-4. The direct oil desulfurization unit at the refinery is the most fundamental process for eliminating the origin of SOx generation. Table 6.3.3-5 below shows the summary of Table 6.3.3-4.

Table 6.3.3-3 : Facilities of energy conversions ector in GTA

(1) Thermal Power Plant in GTA (1994)

Name	Type	Unit	Nominal capacity (Mw)	Generation 1995 (Mwh)	NG (1000 m3/y)	HFO (1000 liter/y)	Gas oil (1000 liter/y)	Total (10^10kca)	Thermal efficiency (%)	Exhaust gas volume (Nm3/hour)
Ray	Gas turbine	40	1,243		458,162	0	147,566			2,064,585
	Steam turbine	0	0		0	0	0			
	(Sub-total)		1,243	1,497,471	458,162	0	147,566	585	0.22	2,064,585
Firouz	Gas turbine	2	25		6,411	0	0			22,166
	Steam turbine	4	50		67622	0	198			168,334
	(Sub-total)		75	173,522	74,033	0	198	73	0.21	190,500
Besat	Gas turbine	3	144		79,547	0	8,482			30,264
	Steam turbine	3	248		140132	210675	3585			946,729
	(Sub-total)		391	1,328,555	219,679	210,675	12,067	431	0.27	1,249,372
	(Total)		1,710	2,999,548	751,874	210,675	159,831	1,083		3,504,457
Montazar	Gas turbine	6	696		475,409	0	58,735			1,964,918
	Steam turbine	4	625		0	943399	7295			2,660,946
	(Sub-total)		1,321	3,486,150	475,409	943,399	66,030	1,442	0.21	4,625,864

(Note) Montazar being for reference, since it is located just outside of boundary line of GTA

(2) Tehran Refinery (220,000 bbl/day) (1994)

Item	Unit	LPG	Gasoline	Kerosene	Gas oil	heavy oil	(Total)
Production	(bbl/day)	6,979	31,791	35,651	52,520	79,021	205,962
	(10^6 liter/y)	405	1,845	2,069	3,048	4,586	11,953
S-content	Iran (%)		0.10	0.15	1.00	3.00	
	Japan (%)		0.025	0.015-0.05	0.200	1.5-3.5	

Table 6.3.3-4(1) : Environmental investment cost for energy conversion sector

(General cost data sourced by JEMAI)

(1) Investment & operation cost of de-SOx and de-NOx plants

	Process	Investment cost	Operation cost
1	De-SOx		
1.1	-Hydrodesulfurization(HDS)		¥8,000-12,000/kl
1.2	-Flue gas desulfurization(FGD)	¥20,000/kw	¥1.5/kw
2	De-NOx		
2.1	- Selective catalytic reduction(SCR)	¥3,500-5,000/kw	
2.2	- Combustion modification(MC)	see item (4)	

(2)Investment cost of FGD

	Process	Reduction(%)	US$/kw	US$/SO2(ton)	US$/TOE
1	Wet FGD	>90%	150-280	350-600	23.4-40.1
2	Spray drier	≒90	140-210	360-540	24.1-36.1
3	Dry injection	≒50	70-120	420-750	15.6-27.9

(3)Investment & operation cost of SCR

	Cost item	Low sulfur oil	High sulfur oil	Coal
1	Investment cost (¥/kw)	3,500	5,000	6,000
2	Operation cost (¥/kwh)	0.20	0.30	0.40

(4)Investment cost for combustion modification

	Type	Cost(¥/m3/hr)
1	LNB+TSC+FGR	657
2	LNB+FGR	491
3	TSC+FGR	475
4	LNB+TSC	480
5	TSC	292
6	LNB	129
7	OSC	26
8	Mean	467

(5)Operation cost for combustion modification

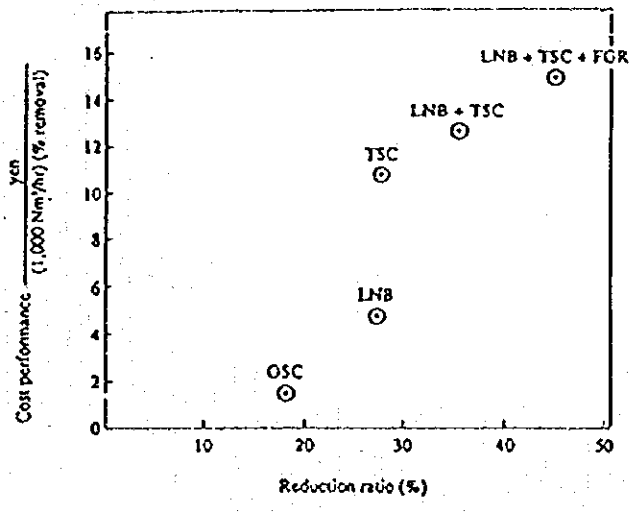


Table 6.3.3-4 (2) : Environmental investment cost for energy conversion sector
(Specific project data)

(1) Investment cost for NOx reduction of Thermal Power Plants (1994)

Plant name	Nominal capacity (Mw)	Thermal efficiency (%)	NG consumption (Nm3/hour)	Exhaust gas volume (Nm3/hour)	SCR cost (Million¥)	LNG+TSC+FGR (Million¥)
Ray	1243	0.22	495,816	5,467,265	5,283	3,592
Firouz	75	0.21	31,341	345,592	319	227
Besat	391	0.27	127,082	1,401,311	1,662	921
Montazar	1,321	0.21	552,021	6,087,026	5,614	3,999

(Note) SCR : ¥4,250/Kw, LNG+TSC+FGR : ¥657/Nm3/hour
Montazar being for reference

(2) Investment cost for HDS plants in Tehran Refinery (1994)

Fraction	Production (bbl/day)	HDS cost (Million¥)
Heavy oil	79,021	36,000
Gas oil	52,520	7,439
Kerosene	35,651	5,305
Gasoline	31,791	
LPG	6,979	
(Total)	205,962	

(Note) US$1=\120=Rs3,000
(Source) AQCC & UNICO

(3) SOx & NOx reduction ratio by process

Process	Pollutants	Reduction ratio (%)
HDS	SOx	80-95
OSC	NOx	<20
LNB	NOx	<30
TSC	NOx	<30
LNB+TSC	NOx	<40
LNB+TSC+FGR	NOx	<50

(Source) Japan Environmental Management Association for Industry (JEMAI)

(Note) Characteristics of natural gas

Comp	Weight (%)	Molecular weight		Volume (%)
CO2	1.10	44	0.56	0.44
N2	1.52	28	1.22	0.95
CH4	83.00	16	116.20	91.03
CO	0.30	28	0.24	0.19
C2H6	10.00	30	7.47	5.85
C3H8	3.30	44	1.68	1.32
C4H10	0.60	58	0.23	0.18
C5H12	0.18	72	0.06	0.04
	100.00		127.65	100.00

(Note)
A= 10.04 (Theoretical air volume dried : Nm3/Nm3))
G'= 11.03 (Exhaust gas volume dried : Nm3/Nm3)
@ Air excess ratio=1.2

(Source) AQCC

Table 6.3.3-5 : Environmental investment cost of energy conversion sector in GTA

(1994 constant price, billion rials)

Sector	Process type	Total construction cost(1994)
Thermal power plants	SCR	174
	LNB+TSC+GGR	6
Refinery	HDS	2,856
(Total)		3,036

② Governmental expenditure for environmental management in Iran

Table 6.3.3-6 illustrates the pollution control expenditure by the government in Japan (1975), which shows the ratio of expenditures at 1.0% versus GNP by the total government inclusive of the central and local. These figures are almost constant since 1974 onward up to now.

Table 6.3.3-6 : Pollution control expenditure by government sectors in Japan (1974)

Sector	% of GNP
Central Government	0.2
Local Government	0.8
Private Enterprises	1.0
(Total)	2.0

(Source) Japan Environmental Management Association for Industry

(c) Projected investment & expenditure for pollution control

Besides the environmental investment to be made by industry and the energy conversion sectors, MOT has to provide GTA with more budgets for infrastructures for environmental control as well as their own public companies in addition to the currently allocated budgets by the central & local governments. Budgets to be needed corresponding to the international levels for air pollution control are estimated on the basis of 1994 constant prices with reference to the ratios described above.

① Summary of key assumption

In the projection of general investment and expenditure in terms of order of magnitude for air pollution control in GTA, a 20% fuel consumption ratio of GTA versus total Iran is used. The estimation procedures described so far are summarized as follows:

(A) Private investment in Iran : 0.3% of GNP

(B) Private investment in GTA : 20% of (A)

(C) Private investment in GTA for air pollution control : 70% of (B)

(D) Governmental expenditure in Iran : 1.0% of GNP

(E) Governmental expenditure in GTA : 20% of (D)

(F) Governmental expenditure in GTA for air pollution control : 70% of (E)

② Projected investment and expenditures (1994 constant price)

In order to estimate expenditures necessary for environmental control in GTA by means of the ratios described above, Table 6.3.3-7 has been produced with reference to the first and second Five Year Plans in Iran. In this table, all the figures are converted into the constant price of 1994 for a consistent basis of comparison.

Table 6.3.3-8 shows the investment and expenditures for the specific projects in the order of magnitude with reference to the data of the OECD countries shown in Table 6.3.3-4. For conversion of the currency, US$1=¥120=Rs3,000 is applied.

Table 6.3.3-7 : General environmental investment & expenditures to be required in GTA

(Billion Rs)

Year	Real GDP (1994 constant)	Central government expend're for envir'tal control in Iran	Private investment in GTA (C)	Governmental expenditure in GTA (F)	Total investment (C)+(F)
1994	115,703	36.8	48.6	162.0	210.6
1995	120,563	38.6	50.6	168.8	219.4
1996	125,626	42.5	52.8	175.9	228.6
1997	130,902	46.7	55.0	183.3	238.2
1998	136,400	51.1	57.3	191.0	248.2
1999	142,129	56.2	59.7	199.0	258.7
2000	148,099		62.2	207.3	269.5
2001	154,319		64.8	216.0	280.9
2002	160,800		67.5	225.1	292.7
2003	167,554		70.4	234.6	304.9
2004	174,591		73.3	244.4	317.8
2005	181,924		76.4	254.7	331.1
2006	189,565		79.6	265.4	345.0
2007	197,526		83.0	276.5	359.5
2008	205,822		86.4	288.2	374.6
2009	214,467		90.1	300.3	390.3
2010	223,475		93.9	312.9	406.7

(Source) Governmental expenditure : 5 year plan in Iran

Table 6.3.3-8 : Projected overall environmental investment and expenditure for specific projects (million Rs)

	Investment item	Owner	Capacity	Total cost	Depreciation
1	Measurement equipment	ORSUITO		1,733	248
2	Small packaged steam boiler	MOT	1,000 kg/h	175	18
3	Power plant				0
3.1	-De-NOx plant (SCR)	Besat power plant	391 Mw	41,550	4,155
3.2	-De-NOx plant (SCR)	Ray power plant	1,243 Mw	132,075	13,208
3.3	-De-NOx plant (LNB+TSC+FGR)	Firouz power plant	75 Mw	5,675	568
4	De-sulfur plant				
4.1	-Heavy oil (HDS)	Refinery	79,021 b/d	900,000	90,000
4.2	-Gas oil (HDS)	Refinery	52,520 b/d	185,975	18,598
4.3	-Kerosene (HDS)	Refinery	35,651 b/d	132,625	13,263
	(Sutotal)			1,399,808	140,055
5	Private investment in GTA	Private sector		71,300/y	*71,300
6	Governmental expenditure in GTA	Government sector		237,500/y	*237,500
	(Sutotal)				308,800
	(Grand total)				448,855

(Note) Depreciation period : plant & boiler 10 year, measuring equipment 7 year

(*) Average amount between 1994 and 2010

(d) Discussion on investment and expenditures to be required for air pollution control in GTA

As shown in Table 6.3.3-7, the governmental expenditures for air pollution control in GTA requires 162-313 billion Rs in 1994-2010 in view of the international requirements.

According to the 5 Year Plan in Iran, however, even the total budget to be allocated for all the pollution control activities meet only about 20% of the requirement for air pollution control in GTA. As shown in Table 6.3.3-8, the projected investment to be required for the specific projects in GTA totals 1,400 billion Rs on an initial cash flow basis, while it amounts to 140 billion Rs on a depreciation basis, which is almost 50% of the governmental expenditures to be required in GTA in 2010.

(e) Reduced amount of pollutants by the specific projects

Reduction amounts of pollutants by the specific projects are projected on the basis of the emission amount in 1994 as shown in Table 6.3.3-9.

Table 6.3.3-9 : Case study for reduction amount of pollutants (1994 basis) (t/y)

Item	Emission before implementation		Emission after implementation		Reduction amount (Balance)	
	SOx	NOx	SOx	NOx	SOx	NOx
1 HDS in Refinery	309,963		30,996		278,967	
2 De-NOx sytem in power plants		11,748		2,635		9,113
3 Fuel replacement with natural ga	252,763	63,209	371	30,673	252,392	32,536
4 Industrial estates	48,888	17,043	0	0	48,888	17,043
5 Small packaged steam boiler		2,200		1,320		880
6 Scenario						
6.1 - DO NOTHING	253,981	95,571	524,585	188,220	-270,604	-92,649
6.2 - COMMON	253,981	95,571	286,237	146,396	-32,256	-50,825
6.3 - BEST	253,981	95,571	83,902	109,304	170,079	-13,733

(Table 7.4.3-1)

As shown in the above table, the following matters can be foresighted.

- Either full installation of HDS at the refinery or full fuel substitution with natural gas would be effective to solve the SOx problem in GTA.
- Regarding NOx emission, fuel replacement with natural gas would lead to NOx reduction of 24%, while de-NOx in power plants would lead to 7% reduction in GTA.
- Relocation of factories to industrial estates would also reduce 18% of SOx and 13% of NOx in GTA, because emission sources would be shifted to harmless remote places.

3) Discussion on financial source (1994 constant price)

As previously suggested in this section, the opportunity cost for energy conservation is roughly estimated as follows, which indicates a magnitude of potential funds for financing environmental investment and expenditures.

(a) Energy conservation amount up to 2010

Based on Table 6.3.3-10, the yearly energy conservation amount in GTA on an average basis can be projected as follows:

- Total energy conservation in GTA (1998-2010)/13 year
  =293/13=22.5 million bbl of crude oil/year

(b) Crude oil FOB export revenues per year

- 22.5 million bbl x US$15/bbl=US$ 338 million

  =1,013 billion rials

(Note) Crude oil price (FOB) : US$15/bbl

The amount above could be used to provide the private enterprises as well as the governmental organization with attractive incentives for energy conservation and pollution control.

Table 6.3.3-10 : Projected energy conservation amount up to 2010 in GTA

(Million bbl of crude oil)

Year	Assumed energy consumption in GTA (DO NOTHING scenario)	Consumption growth ratio (5.1%/year)	Energy comservation ratio	Energy conservation volume
1994	153	1.000		
1995	161	1.051		
1996	169	1.105		
1997	178	1.161		
1998	187	1.220	0.010	1.9
1999	196	1.282	0.022	4.3
2000	206	1.348	0.033	6.8
2001	217	1.417	0.045	9.8
2002	228	1.489	0.057	13.0
2003	239	1.565	0.068	16.3
2004	252	1.644	0.080	20.1
2005	265	1.728	0.092	24.3
2006	278	1.816	0.103	28.6
2007	292	1.909	0.115	33.6
2008	307	2.006	0.127	39.0
2009	323	2.109	0.138	44.5
2010	339	2.216	0.150	50.9
(Total)	3989			293.1

6.4. Necessities of establishment of integrated monitoring and inspection system

6.4.1. Necessities of establishment of integrated supervision system

As pointed out in clause 2.1. and 6.2., environmental activities in the central government and also in the MOT are not so active, especially, concerning monitoring of the ambient air, identification of emission sources. Improvement and strengthening of the related organization, therefore, are recommended both respecting institutional and technological fields as presented below.

(1) Expansion and strengthening of monitoring stations

There are two kinds of monitoring stations consisting of an ambient air monitoring station and a road side monitoring station intended especially to measure pollutants emitted from vehicles. Almost all monitoring stations in Tehran, are deemed to be road side monitoring stations, not an ambient air monitoring stations. The latter should be located where any particular sources do not dominantly influence measurement and should represent average concentration of the ambient air pollutants in the region.

Monitoring stations under the central government and MOT are marked in a black and white circle in Figure 7.3.1-2. It is recommended to install additional seven ambient air monitoring stations as starmarked and three road-side monitoring stations marked as ◆ in accordance with results of the study.

(2) Collection and establishment of integrated ambient air data base

As mentioned in Chapter 3. , there are many ambient air monitoring stations in GTA under the DOE, MOH, MOO, NAEC and AQCC. While they are installed by these public organizations for the purpose of their own specific objectives, no organization combines these data for the purpose of analysis of ambient air in GTA, and there are no systems for disclosing these data to the public excluding of AQCC's activities through a news paper publication and graphical indications on the monitoring stations. These valuable data should be utilized for policy makers

aiming to reduce of air pollution and to develop institutional systematizing.

Therefore, all these data should be centralized at DOE and MOT because they are principally responsible for monitoring and supervision of present situation of ambient air of GTA. Annual monitoring data including the results of analysis and simulation should be made available to the public.

For these purposes, a working group should be organized under the coordination by DOE and inviting participants from DOE, MOH, MOO, MOI, and other ministries of central government concerned as well as AQCC, ORSUITO and others in MOT. The group should be requested to make guide-lines concerning functions of each organization and demarcation between them. Responsibilities of monitoring of GTA should be borne by MOT. The group should be named the 'National Committee for Ambient Air Monitoring' whose meeting should be held at least once a year. The principal role of DOE should be confirmed to be in the development of technology in national level and setting and enforcement of laws and regulations concerning ambient air standards and procedures for observation and measurement of ambient air etc. including coordination with WHO or IBRD etc.

(3) Monitoring of emission from vehicular sector

At present, there are no systematized activities of measurement of emission factors of vehicles in Tehran, except AQCC's measurement of motor cycles emission, a chassis dynamo test approach recently started by RIPI, research Institute under the MOO, and AIRIC under MOI, therefore, measurement of emission factors conducted in the Study will be deemed as a first experience in Iran that reveal the emission amounts from the vehicular sector.

Therefore, data gathering on emission sources through strengthening of an inspection system and improvement and strengthening of maintenance workshops as well as building of a data base through ambient and road side monitoring should be contributed to policy making for reduction of air pollution on a medium and long terms basis. For this purpose, the following activities shall be stepped up:

1) Strengthening and improvement of vehicle registration systems

2) Attainment of vehicle inspection with complete coverage and strengthening of its link with to maintenance enforcement

3) Improvement of a vehicle inventory through the above inspection and maintenance

4) Accumulation of data revealing a relationship between the Chassis dynamo-test and the idling test

5) Periodical conductance of traffic volume survey

(4) Inventory preparation of stationary emission sources and establishment of flue gas inspection system

As remarked in clause 6.3., there are no systematic inventory system concerning the manufacturing industries , commercial and households including hotel, restaurant etc..

Therefore, ORSUITO should be officially authorized as a responsible organization in GTA/MOT for conducting of inventory preparation including emissions sources under the Central Government. The following measures should be initiated as soon as possible;

1) Execution of an annual inventory survey

2) Analysis of the present pollution status classified into the manufacturing sub-sectors

3) Promotion of compulsory inspection of combustion facilities of emission sources

4) Establishment of public laboratories for flue gas inspection

5) Promotion of out-side private inspection activities in GTA

(5) Improvement of pollutants measurement technology

Because there are not enough monitoring stations for measurement of the ambient air, and very few in the flue gas measurement, so, both of them should be

strengthened and improved.

For this purpose, in addition to the activities discussed under (2) and (4) above, such activities in the Central government or MOT to support the measurement of the ambient air and flue gas shall be promoted and established, and a dissemination of technologies or training required for the activities shall be conducted to the public. And compulsory inspection once per month in the large pollutants emitter should be introduced and gradually expanded to all emitter.

In order to promote inspection of flue gas, man-power development in measurement of ambient air and flue gas analysis covering analytical researchers who are expected to carry out micro analysis of heavy metal in the TSP in the ambient air, and analysis of NMVOC, HC, CO etc. should be strengthened in the whole country. In addition, supporting activities including academic and scientific symposiums and training seminars on analytical chemistry should be promoted including followings:

1) Standardization of analysis and measurement method for ambient air quality
2) Standardization of analytical method of flue gas
3) Follow-up research in micro-analysis

(6) Strengthening of environment management system targeting law/regulation for emission control

In line with the above environmental management system and technological measures gradually, study for promotion in emission regulation and control should be started.

These could not be achieved without studying a sub-sectoral technologies as well as a wide range of environment and social activities.

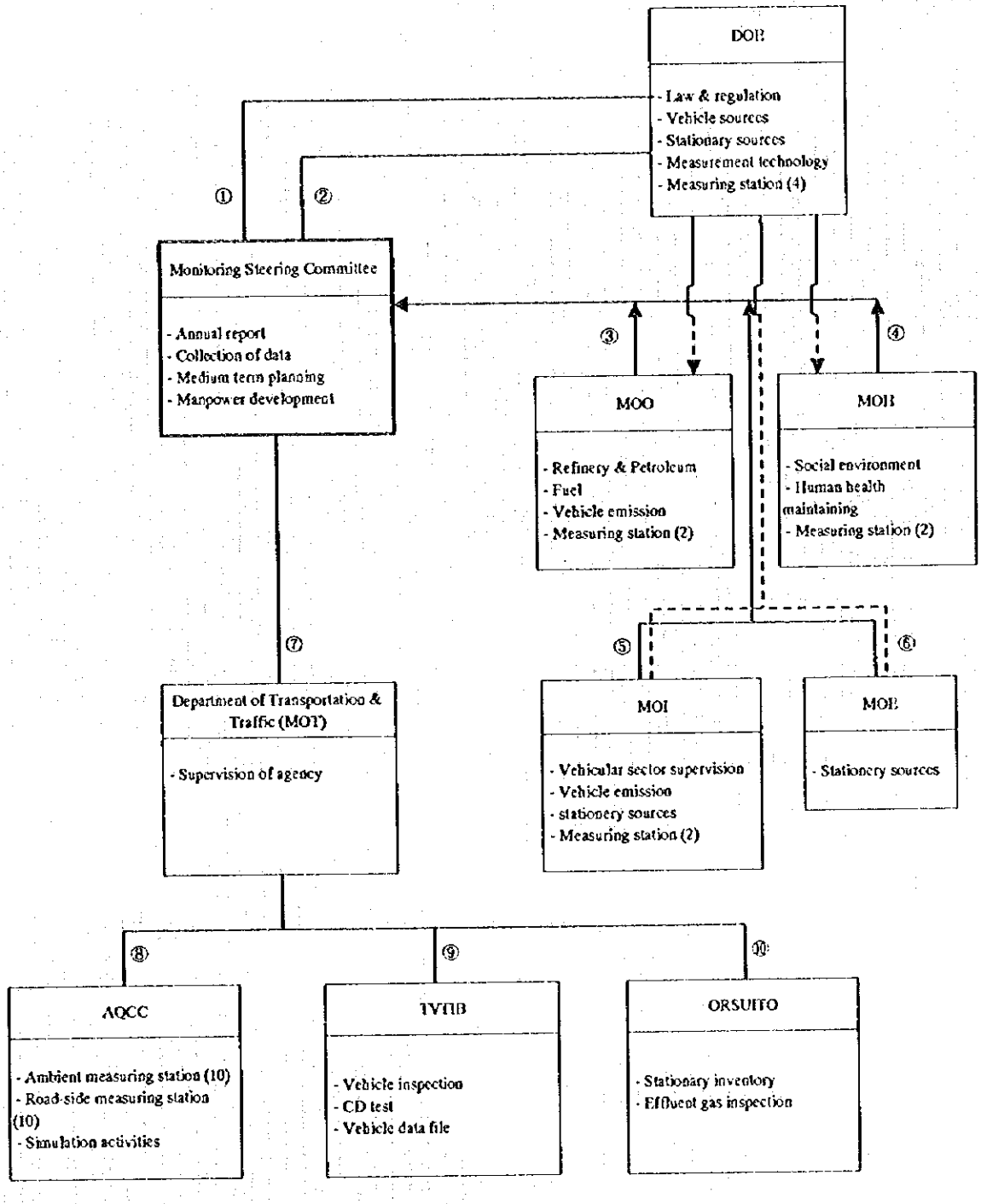
In connection with the above, DOE intends to introduce a regulation on environmental assessment at the order of SCEP. The orientation paper is now

circulating among the Ministers. Before its introduction, reviews should be made on the present environmental management in other countries, sub-sectoral manufacturing technology, emission quantity from emission source and environmental investment cost and benefit. National institutions and man-power should be upgraded.

1) Preparation of an emissions inventory for vehicle and stationary sources
2) Analysis of present situations of emission from vehicles and stationary sources
3) Impact analysis of introduction of regulation and control of emission sources
4) Emissions control and regulation planning
5) Study of introduction of environmental assessment
6) Information dissemination to the industries on ISO-9000 and ISO-14000

Environmental management strengthening air pollution control were reviewed. Concerning the above six categories, indicative and targeted inter-organizational linkage formation among the government in the MOT is shown in the Fig.6.4.1-1.

Figure 6.4.1-1 Activities Links for Integrated Monitoring and Inspection System



①Request for administrative support

②Advisory and administrative support

③Periodical reporting & working group

④Working group & health risk assessment

⑤Periodical reporting & working group

⑥Working group

⑦Actual chairbody & working group coordination

⑧Coordination body responsible for reporting & analysis

⑨Vehicle emissions inventory

⑩Stationary emissions inventory

6.4.2. Role of central government

Six activities mentioned in the previous clause all shall be recommended to promote under the Central government, these split of work between the related ministry and MOT are shown in the Table 6.4.2.-1.

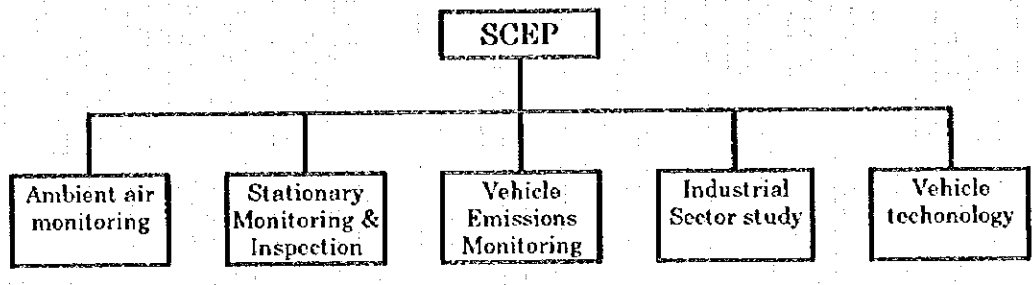
Table 6.4.2.-1 Division of Responsibility for strengthening of monitoring activities

No.	Items required	Central Government					MOT
		DOE	MOH	MOO	MOI	MOE	3/
1.	Expansion of monitoring station						
1.1.	Number of stations	7	2	2	-	-	10
1.2.	Ambient air measurement	7	2	2	-	-	10
1.3.	Meteorological measurement 1/						10
1.4.	Road side stations	1	1	2	1	-	10
2.	Integrated data collection						
2.1.	By-monthly reporting to DOE & MOT 2/	#	*	*	-	-	#
2.2.	Issuance of annual report						*
3.	Monitoring of vehicular emission						
3.1.	Strengthening of vehicle registration	*			*		*
3.2.	Strengthening of inspection and maintenance	*			*		*
3.3.	Up-grading of vehicle inventory						*
3.4.	Expansion of CD test in inspection center				*		*
3.5.	Periodical survey of traffic volume						*
4.	Monitoring of stationary emission						
4.1.	Execution of annual inventory survey						*
4.2.	Analysis of sub-sector wise pollution status	*	*	*	*	*	
4.3.	Compulsory inspection of flue gas	*					*
4.4.	Expansion of public inspection laboratory						*
4.5.	Introduction of outside inspection company						*
5.	Up-grading of air pollutant measurement technology						
5.1.	Standardization of ambient air analysis method	*					
5.2.	Standardization of flue gas measurement method	*					
5.3.	Follow-up research of micro-analysis method	*					
5.4.	Publication of environment analysis journal	*					
6.	Introduction of law of emission restriction						
6.1.	Evaluation of domestic manufacturing level	*	*	*	*	*	
6.2.	Cost and effect analysis	*	*	*	*	*	
6.3.	Master plan of emission restriction plan	*	*	*	*	*	*
6.4.	Preparation of EIA draft	*	*	*	*	*	*
6.5.	Introduction of ISO-9000 & ISO-14000	*	*	*	*	*	

Remarks:
1/ Only required for wind meter, wind direction meter and radiation measurement
2/ #; be supplied
3/ be read as AQCC, ORSUITO, TTCC, TTTO,TCITS, and TVTIB

The role of the Central government regarding monitoring activities for the ambient air polluting substances should be executed by five working groups for 'Monitoring action plan for ambient air' shown in Fig. 6.4.2.-2

Fig. 6.4.2.-2 Working groups for monitoring action plan for ambient air



Namely, following the authorization of DOE and SCEP, five working groups should be organized and each group should be led by representative of DOE, Universities, consulting groups and each sub-sector. In addition, each ministry Meeting is recommended to be held quarterly. The activities of each group are explained below;

(1) Ambient air monitoring

- Authorization of supervisery organizations of ambient monitoring stations and road side monitoring stations in GTA
- Agreement on bi-monthly disclosure and exchange of observed data and publication of annual report of monitoring observation

- Establishment of a working group for standardization of measurement and an analytical method for pollutants in the ambient air
- Organization of a micro-analysis working group and determination of a role of each parties
- Publication of a monthly environment analysis journal
- Promotion of receiving of foreign experts and overseas dispatching of Iranian experts

(2) Stationary monitoring and inspection

- Preparation of monthly self-inspection procedures for flue gas measurements
- Preparation of improvement plans for district inspection laboratories under the ORSUITO of MOT
- Promotion of establishment of an analytical center and its privatization policy
- Promotion of information dissemination of environment assessment
- Promotion of establishment of training courses for flue gas measurement
- Promotion of joint technical cooperation with foreign countries

(3) Vehicle emission monitoring

- Plan of roadside monitoring stations
- Strengthening of a vehicle emission inventory
- Collection and accumulation of emission factors of vehicles
- Publication of the journal of 'Vehicle Pollution'
- Promotion of technical cooperation projects with foreign countries

(4) Industrial sector study

- Study and planning of an emission inventory system
- Execution of a sub-sector study on the manufacturing industries
- Preparation of an air pollution reduction master plan
- Promotion of technical cooperation projects with foreign countries

6.4.3 Role of the Municipality of Tehran

Division of responsibility for cooperation activities of the working group with the central government and the role of MOT is shown in Table 6.4.3.-2. In order to strengthen activities in the field of monitoring of the ambient air, vehicles and stationary emission, staff shall be increased by 20-30 above the present number 50-60, the required cost for facility expansion and improvement will be US$15 million. Also the following comment should be noted:

(1) Expansion of monitoring stations

Expansion of 10 stations should be completed under the three phase expansion plan; four, three, and three stations in each phase. These stations should be supervised by AQCC during installation and start-up stages and these stations should be privatized within three years after the completion of the last stage.

In addition to the above, MOT's participation as observer to the working group of standardization and micro-analysis is required. Man-power will be needed additionally to execute these functions.

(2) Data base formulation for vehicle emission

The objectives of the database should focus on accumulation of essential data for vehicle emission collected up to now by TVTIB, TCTTS, TTCC, and AQCC etc. Such data will be key for the scrappage program and improvement of engines and parts including quality improvement of vehicle fuel.

(3) Strengthening of monitoring and inspection of flue gas

The objective of the project is to conduct excellent and influential flue gas inspection by establishing regional testing laboratories around the southern district of GTA to help small and medium scale industries in air pollution prevention and process improvement.

(4) Utilization and cooperation with overseas technical cooperation scheme

Though miscellaneous development tasks for air pollution reduction have been recognized in MOT, very few practical actions have been made , partly due to delayed decision and financial difficulties in MOT, but mainly due to the lack of the key organization which is actively working for air pollution issues.

Therefore, in addition to the above reformulation of MOT's activities, it is recommended to receive bilateral or multilateral foreign technical cooperation to the DTI of MOT including short or long term staying of experts based on the GEF project and this Study.

Chapter 7

Recommended master plan and implementation schedule

7. Recommended Master Plan and Implementation Schedule

7.1 Medium and long term master plan for air pollution control in the GTA

7.1.1 Master plan

As discussed in the previous chapter, it is understood that ambient air quality in the year 2010 respecting CO, HC, SOx, NOx and SPM will far beyond the level of the WHO standard and that strategic execution of countermeasures in the fields of air pollution control management, vehicular sources and stationary sources is the key.

Therefore, a medium and long term master plan targeting the year 2010 will be presented below.

(1) Basic principles for a master plan

1) The socio-economic development plan was based on the SFYDP reflecting the sectoral statistical data for 1994 as well as those for 1997 for some important cases.
2) A master plan for the air pollution reduction in GTA should be elaborated covering the cross-sectoral issues on the national level, which are beyond the matter of MOT. These countermeasures are also reviewed and presented in this report.
3) Neither the emission data in GTA nor the data measured and observed during the Study for elaboration of the countermeasures are not enough. One of the important countermeasures should target an establishment of the air pollution management system aiming the accumulation of data base for policy making for air pollution reduction.
4) However, urgent and feasible countermeasures for air pollution emitted from vehicular and stationary sources have been presented for execution in consideration of present severe condition of the GTA.

5) The WHO standards for ambient air quality has been adopted for the target air quality in the 2010.

(2) A medium and long term master plan

An indicative medium and long term master plan is presented in the Fig.7.1.1-1, whose outlines are explained below:

1) MOT is requested to prepare within the financial year 1997/98, 'a master plan for air pollution reduction in the GTA' based on the outcomes of the IBRD's TERP project and JICA Study including formation of working group for elaboration and detailed planning of the urgent sub-projects as listed below.

- Establishment of an inventory system
- Expansion of monitoring stations in GTA
- Enhancement of public transport
- Expansion of the I/M program
- Rehabilitation of automobile industries
- Renovation of in-use vehicle including mobile parts
- Improvement of the quality of vehicle fuel
- Study in the economy and expected environmental load of passenger car
- Plan of trial projects on the TDM in GTA
- Detailed scrapping program on high aged vehicles
- Sub-sector studies in manufacturing industries
- Introduction of advanced combustion and energy saving technologies
- Introduction of cleaner production technologies
- Preparation of air pollution prevention guidelines for manufacturing industries
- Promotion of joint projects with foreign countries

Fig. 7.1.1-1(1) Master Plan for Air Pollution Control for Municipality of Tehran

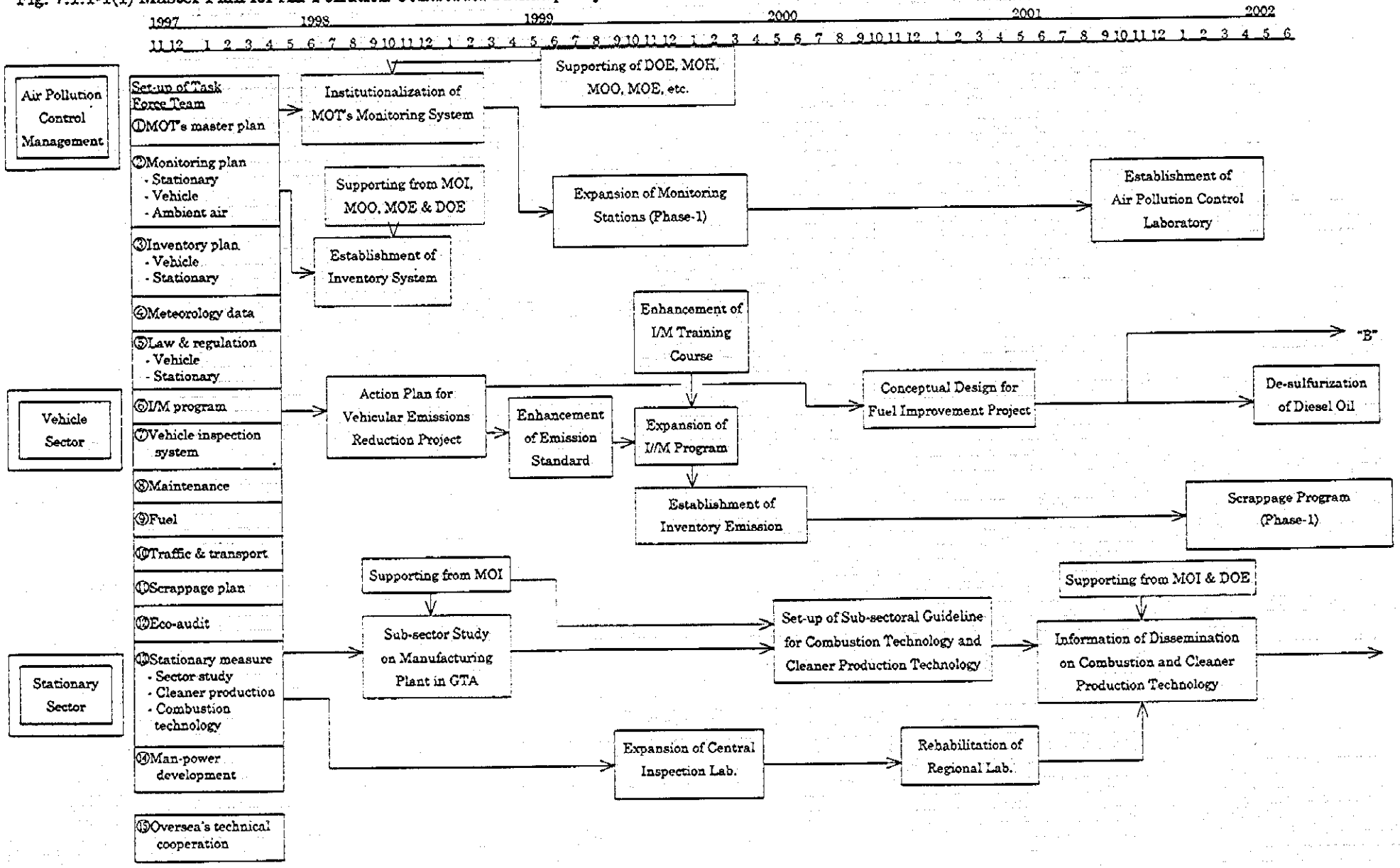


Fig. 7.1.1-1(2) Master Plan for Air Pollution Control for Municipality of Tehran

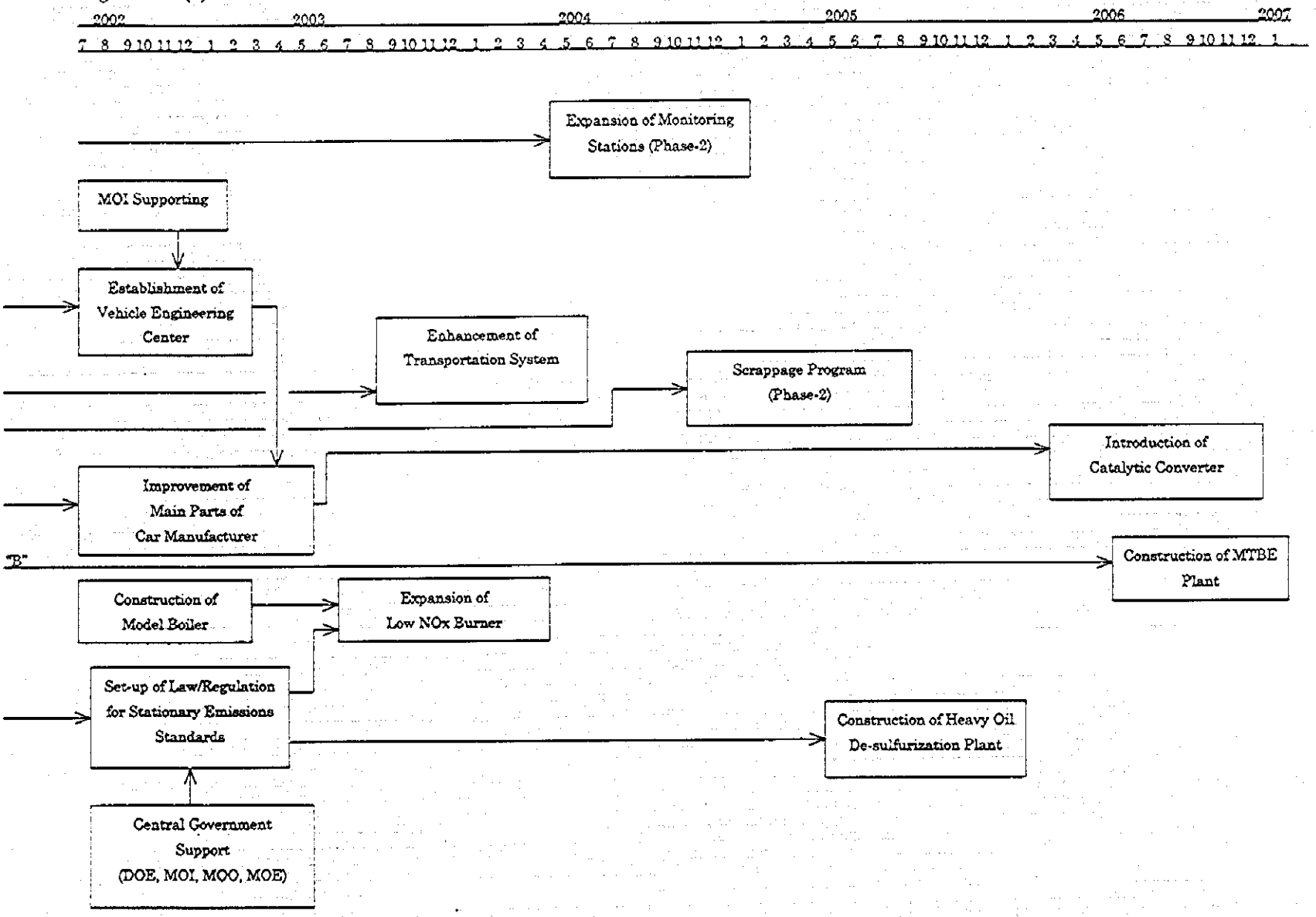
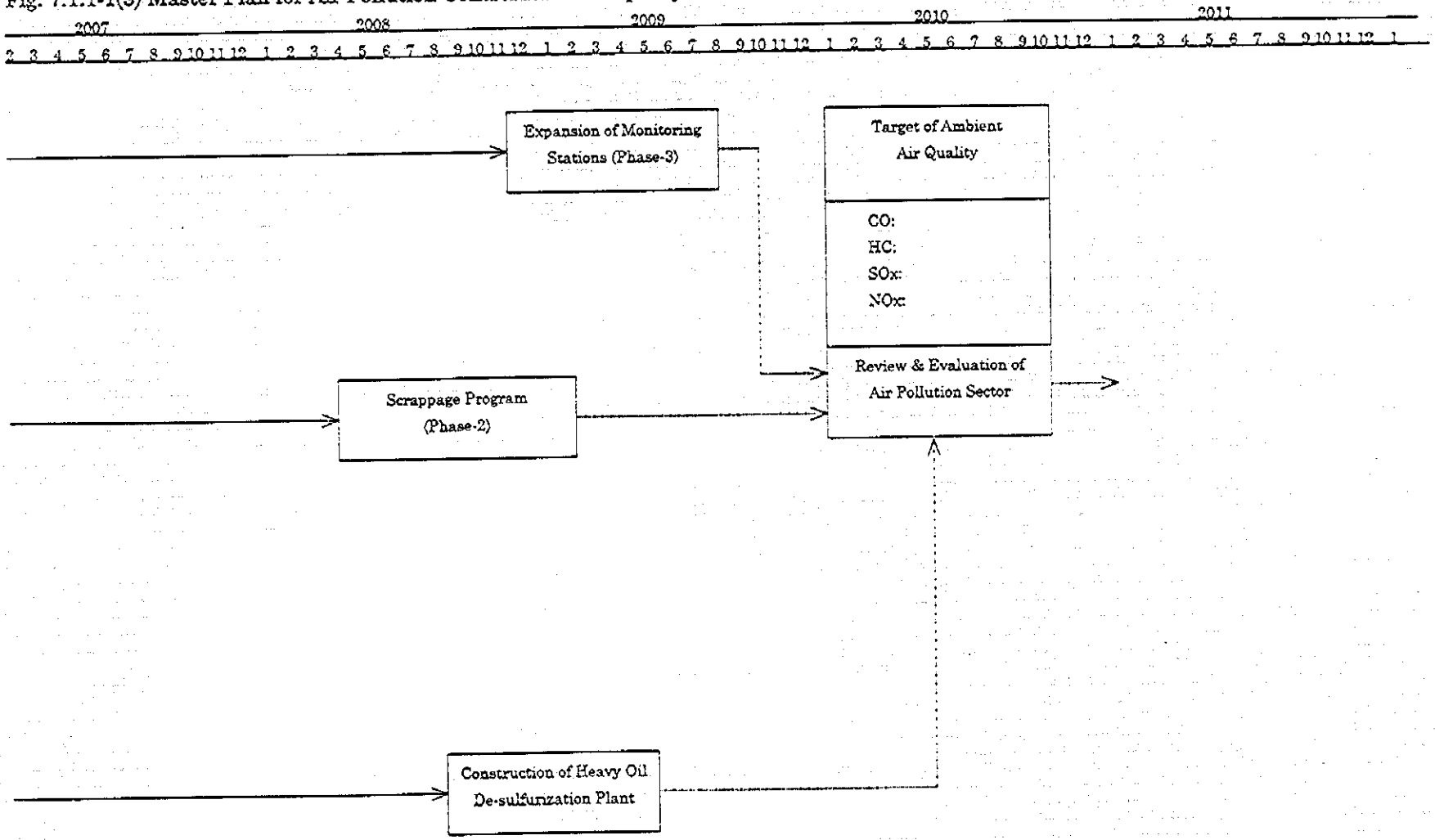


Fig. 7.1.1-1(3) Master Plan for Air Pollution Control for Municipality of Tehran



2) There are 13 years until the year 2010. In consideration of the present availability of related data base and extents of analysis in Tehran, it is recommended to divide these periods to three phases: the five year first phase from 1998 to 2002, the five year second phase from 2003 to 2007 and the three year third phase from 2008 to 2010. For each phase, the following measures would be taken:

(1) Execution of urgent sub-projects

(2) Establishment of management systems and organizations for air pollution control in GTA

(3) Detailed clarification of air pollution mechanism through establishment of a monitoring and inspection system including improvement of an inventory system

(4) Preparation of a detailed implementation plan for large scale countermeasure projects to be executed in phase 2

(5) Implementation of all measures for renovation of mobile manufacturing industries in Iran

(6) Execution of a sub-sector study followed by preparation of a master plan and guidelines for the sub-sectors in the manufacturing industries

During the second phase;

(1) Implementation of large scale countermeasure projects planned in phase1

(2) Modernization of automobile industries

(3) Modernization of manufacturing industries in MOT

After phase2, almost all major pollution issues would be overcome as far as CO, HC and SOx are concerned.

During the third phase;

Evaluation of the implemented projects and execution of countermeasure for NOx reduction would be carried out in line with the environmentally advanced countries' present situations.

3) During the phase1, any projects requiring a large amount of investment will not be executed. They need in-depth analysis of the present situation of the issues as well as basic and detailed project planning including cost estimation. Therefore, during the phase1, urgent projects including establishment of an inventory system, expansion of monitoring stations and strengthening of central inspection lab. In ORSUITO, enhancement of the I/M program and scrappage program phase 1 will be implemented.

4) During the phase2, second phase expansion of monitoring stations for air pollution management and improvement of public transportation systems, improvement of mobile parts, establishment of a vehicle engineering center aiming supporting functions for in-use vehicles, introduction of a catalytic converter and the second phase scrappage program will be implemented . Particularly, for the stationary sector, introduction of combustion technology and cleaner production technology, information dissemination of low NOx burners etc. combined with construction of a model boiler aiming at information dissemination of needs for energy saving will be implemented.

5) During phase3, third phase expansion of monitoring stations for air pollution management, the third phase scrappage program and start-up of operation and distribution of MTBE in vehicular sector and start-up of a hydro-desulfurization plant will be executed.

The countermeasures during the above three phases are expected to contribute to reduction of the targeted pollutants to the level of the WHO standards of CO,

SOx, NOx and SPM, i.e. 2.5ppm, 17～26ppb, 38ppb and 60～90 $\mu g/m^3$ respectively.

(3) Cost estimation of sub-projects in the master plan

Table 7.1.1-1 is a summary table for the recommended sub-projects in the master plan showing their periods of start-up after the planning and construction, the estimated cost required, expected reduction amounts of CO, SOx and NOx and the cost required per unit reduction weight (ton) of the targeted pollutant.

Table 7.1.1-1 Summary of countermeasure for air pollution control for Greater Tehran Area

No.	Countermeasure	Implemetation period 1/	Project cost (US$1000)	xpected amount of pollutants to be reduced(ton)			
				CO	SOx	NOx	Cost(US$/ton) 2/
1	Air pollution control management						
1-1.	Establishment of inventory system	1998	283		12699.3	4774.9	59.27
1-2.	Ambient air monitoring system	1999	522				
1-3.	Municipal environment research and promotion Center (establishment)	2003	24,630		5079.72	2864.94	
1-4.	Expansion of monitoring stations	1999, 2003, 2007	2,750		2539.86	1909.96	
2	Vehicular sources						
2-1.	Enhancement of public transport system	2003	231,150	124,021	1,251	5,942	1863.8
2-2.	Strengthening of I/M programme	1998	25,300	165,000			153.33
2-3.	Enforcement of emission standard	1998	354	41,340	500		8.56
2-4.	Establishment of I/M training course	2000	1050	82,680			12.7
2-5.	Establishment of vehicle engineering center	2001	8,520	110,000	500	10,000	77.45
2-6.	Improvement of main parts of car manufacture	2000	5,560	220,000			25.27
2-7.	Introduction of catalytic converter	2005	148,780	110,000		30,000	1352.55
2-8.	Desulfurization of diesel oil	1999	44780		6,000		7463.33
2-9.	Construction of MTBE plant	2007	139,980	145,000			965.38
2-10.	Implementation of scrappage programme	1999, 2004, 2008	53,560	152,000			352.37
2-11.	Promotion of public awareness	1998	400	24804.12			
3	Stationary source						
3.1	Improvement of regional inspection lab.	1999, 2003	990		10159.4	3819.92	97.45
3-2.	Investigation and preparation of master plan on manufacturing sub-sector in GTA	1998	1,310		25398.6	11459.8	51.58
	1) Sub-sectoral study 2) Measure for saving of energy 3) Introduction of cleaner production technology 4) Nox reduction measure		114 1820 190 340				
3-3.	Construction of de-sulfur plant	2005	976,490		153,000		6382.29
3-4	Fuel conversion to natural gas	2005	3,140		200,000	40,000	16

Remarks: 1/ Operation start-up
2/ Per ton of targeted pollutants

7.1.2 Expected role of the organization for execution of the master plan

Because nearly all of the recommended sub-projects in the master plan concern the cross-sectoral fields beyond the responsibilities of MOT, MOT will not be able to overcome these issues by itself. In planning and execution stages, therefore, it is recommended that the role of the central government and division of their responsibilities should be clarified as mentioned below.

(1) Expected role of the central government

Table 7.1.2-1 shows the expected role of the central government in the recommended sub-projects in the master plan. These supporting activities concerning execution of the project, participation in the working group for review/analysis of the issues, preparation of a plan through technical and administrative supports will be explained below.

1) DOE

-Participation in and administrative supports of the working group on establishment of an inventory system for the vehicular and stationary sector

-Technical and administrative supports for national level authorization and execution of establishment of ambient air monitoring systems, common utilization of data and expansion of monitoring stations including road side stations in the GTA

-Promotion of improvement of technology for measurement of air pollutants on the national level

-Administrative supports of inspection of flue gas in the GTA

-Authorization and approval of stepwise enforcement of the emission standard for the vehicular exhaust gas

-Setting forth and approval of environmental related standards

-Administrative supports of the sub-sector study and preparation of sectorwise guidelines for emission control

Table 7.1.2-2 Role of the central government for the project

No.	Countermeasure	MOT	Central Government					
			DOE	MOI	MOO	MOE	MOH	IRIMO
1	Air pollution control management							
1-1.	Establishment of inventory system	EX	WG	WG	WG	WG		WG
1-2.	Ambient air monitoring system	EX	WG	WG	WG	WG	WG	WG
1-3.	Municipal environment research and promotion Center	EX	AA					AA
1-4.	Expansion of monitoring stations	EX	AA				WG	WG
1-5.	Improvement of regional inspection lab.	EX	AA	AA		AA		
2	Vehicular sources							
2-1.	Enhancement of public transport system	EX						
2-2.	Strengthening of I/M programme	EX		TA & WG				
2-3.	Enforcement of emission standard	EX	TA & WG	TA & WG	TA & WG			
2-4.	Establishment of I/M training course	EX		TA				
2-5.	Establishment of vehicle engineering center	EX1 1/		EX2				
2-6.	Improvement of main parts of car manufacture	AA & TA		EX				
2-7.	Introduction of catalytic converter	EX		TA & AA				
2-8.	Desulfurization of diesel oil			TA & AA	EX			
2-9.	Construction of oxygenated fuel additive plant			TA & AA	EX			
2-10.	Scrappage Programme	EX		TA & AA	AA			
2-11.	Promotion of public awareness	EX	TA & AA	TA	TA			
3	Stationary source							
3-1.	Investigation on a present status of sub-sector	EX	TA	TA	TA	TA	TA	
3-2.	Dissemination of information on cleaner production technology.	EX	TA	TA	TA	TA		
3-3.	Improvement of combustion technology	TA		TA	EX	TA		
3-4.	Construction of model plant for de-sulfurization of flue gas	TA		TA & AA	EX			
3-5.	Construction of model combustion boiler	TA		TA & AA	EX			
3-6.	Improvement of burner	TA		EX				

Remarks: EX: Execution body
WG: Supporting in the working groupe
TA: Technical assistance
AA: Administrative assistance to the project planning and implementation
1/: EX for in-use vehicle

2) MOI

-Preparation of sector policies for modernization of automobile manufacturing industries and undertaking of leadership

-Preparation of a strategic action plan for revamping of the auto-parts manufacturing industries including promotion of temporary import of overseas parts

-Execution of a sub-sector study and preparation of sectorwise policies and guideline for modernization of the manufacturing industries including promotion of technology for air pollution control and cleaner production

-Administrative and technological support of MOT's project improvement of in-use vehicles

3) MOO

-Participation in the working group on establishment of an inventory system and monitoring system

-Participation in the working group on the periodical change in the emission standard of vehicle exhaust gas as a representative of the vehicle fuel sector

-Preparation of vehicle fuel policies and execution of vehicle fuel improvement projects

-Administrative and technical support of fuel for promotion of a high-aged vehicle scrappage program

4) MOE

- participation in the working group on establishment of an inventory system and a monitoring system
- Administrative support of inspection activities for flue gas in the GTA
- Administrative support of establishment of an inventory system for the stationary sources
- Execution of a sub-sector study and preparation of sectorwise policies

and guidelines for modernization of the manufacturing industries including promotion of technology for air pollution control and cleaner production

5) MOH

- Participation in and administrative supports of the working group on establishment of an inventory system on the vehicular and stationary sectors
- Technical and administrative supports of national level authorization and execution of establishment of ambient air monitoring systems, common utilization of data and expansion of monitoring station including road side stations in the GTA
- Promotion of improvement of technologies for measurement of air pollutants on the national level
- Data collection and evaluation of health risk analysis in the GTA and technical and administrative supports of MOT's public campaign for reduction of pollutants in GTA

6) IRIMO

- Technical and administrative supports of national level authorization
- Establishment of ambient air monitoring systems and common utilization of data and expansion of monitoring stations in GTA
- Participation in the working group and technical and administrative supports of common utilization of meteorological data in GTA
- Promotion of improvement of technologies for measurement of meteorological data in GTA
- Management of meteorological observation facilities in GTA
- Technology development on analysis of a meteorological data observed in GTA

(2) Role of the Municipality of Tehran

Firstly, as recommended in the master plan, more detailed collection on ambient air quality covering the whole area of GTA and more detailed data on emissions both for vehicle and stationary sources followed by analysis of the mechanism on air pollution in GTA are required, even though rough estimation was made in the study.

Secondly, among others, evaluation and preparation of an action plan for updating vehicle manufacturing technologies and in-use vehicles for the purpose of reduction of pollutants emissions are urgently required in cooperation with the central government. For this objective, formation of a working group in the MOT is essential.

Thirdly, it is recommended for AQCC to execute a sub-sectoral study for modernization of manufacturing industries in GTA in cooperation with foreign countries in concert with formation of the working group of manufacturing industries in GTA.

For reference, the recommended contents of 'Air pollution control management plan' to be drafted by MOT is listed in Table 7.1.2-2.

Table 7.1.2-2 Recommended contents of environmental management plan for Municipality of Tehran for air pollution reduction

NO.	Sub-title	Contents to be described
1.	Basic policy of Master plan	Background, basic philosophy for the plan, scope of the targeted area, target, period and major issues in the plan etc. shall be presented
2.	Out line of the targeted area	(1)Natural environmental condition for topography, meteorological, water and animal/plants etc. (2)population, (3)industries for outline of the sector, manufacturing, agricultural/fishery and commercial etc. and (4)urban environment for land utilization, urban planning, urban facilities and transportation/traffic in the area shall be reviewed
3.	Present status of air pollution in the GTA	Overviews on the air pollution and pollutants wise outline review for CO, HC, SOx, NOx, SPM and photochemical oxidants shall be presented
4.	Development of countermeasure for air pollution control in the GTA	(1)Basic framework of the measure, (2)Urban planning, (3)Countermeasure for CO, HC, SOx, SPM, NOx and oxidants shall be presented and favorably measure for noise shall be included
5.	Related countermeasure for air pollution control in the GTA	(1)Other measures for air pollution reduction including improvement of urban facilities, (2)urban health improvement including measure for damaged inhabitants due to air pollution, health investigation promotion and improvement of school health environment etc. (3)measure for small scale industries including relocation plan, promotion of industrial estate and financial incentive for air pollution reduction etc. and finally, (4)promotion of environmental education shall be proposed
6.	Institutionalization set-up for air pollution control in the MOT	(1)Improvement of law and regulation, (2)Strengthening of inspection activities for emission sources, (3)Strengthening of environmental monitoring, (4)Improvement of investigation and research activities and (5)Improvement of environmental management system in the MOT
7.	Contents of the master Plan	(1)Supervisory plan and procedure of the project,(2)Outline of the cost estimation, (3)Plan and procedure for supporting group of the project, (4)Linkages with related governmental plan of the projects shall be presented

7.2 Meteorological observation plan

7.2.1 Strengthening of meteorological observation

Meteorological data are necessary for a simulation model of pollutant diffusion not only as the basic data for the model development but also as input data required in the running of the model. The indispensable meteorological data are the wind direction, wind speed and atmospheric stability which are derived from solar radiation in the daytime and radiation balance (or cloud amount) in the night-time. In Tehran, these data are obtained and accumulated by IRIMO. However, as IRIMO was organized for the purpose of prevention of a natural disaster and industrial development, the observation system does not satisfy some of the conditions for analysis of air pollution. As for solar radiation, though IRIMO takes the summed up value, the instantaneous value is required for evaluation of atmospheric stability. Therefore, the instrument being in use should be replaced by the one which can measure and record the instantaneous value.

Besides, because the observation and data input procedures are depending on manual work of staff for the present, processing of the data base is time consuming and may have some input mistakes. For that reason, it is recommended to change the current observation system to the automatic system that can take data from a sensor and transmit them to a host computer at IRIMO. The introduction to each meteorological bureau of the same type automatic meteorological observation system with the one now employed on trial at the Aghdasiyeh Meteorological Bureau is expected to make the observation more reliable and labor saving.

Meteorological observation in Tehran is made by DOE and AQCC as well as by IRIMO. These observations (by DOE and AQCC), however, are incidental to the pollutant monitoring at the stations. Because most stations are surrounded by buildings, the wind data are considerably affected by them and show the locality; that is, they do not represent the wind in the surrounding extensive area. Therefore, the available wind data for the analysis and evaluation of air pollution are only the IRIMO data. It is proposed that the several meteorological stations in addition to the current four stations in Tehran should be established after due consideration of the influence of topography and buildings.

Since automobiles are regarded as the major source of the air pollution, temperature inversion in the lower atmosphere is one of the most important phenomenon affecting the pollutant concentration. Because inversion corresponds to the condition that the atmosphere is so stable and stratified, the pollutant diffusion and vertical advection are restrained. Such inversion is observed with a captive sonde, low level sonde or thermometers installed at a high steel tower. Sonde observation has an advantage in that the observation site is optional and data can be obtained up to the altitude over the convective mixing layer that affects the pollutant concentration. However, this kind of observation needs much labor and money. On the other hand, though the tower observation is suitable for long term evaluation of the vertical temperature gradient in the lower atmosphere, choice of observation sites and height of the tower are restricted.

As some procedures of observation require skill and experience, it is suggested to establish a meteorological survey company and award it a contract for observation, so that IRIMO and AQCC may devote themselves to the analysis of observation data.

The detailed suggestions for introduction of the new observation system are shown below.

① Introduction of the automatic controlled system for the meteorological observation

a. Observation sites to be equipped with the new system

Meteorological Observation Bureau : Three Bureaus are to be equipped except Aghdasiyeh which already has the system.

Additional observation point : Three points are to be added to the observation network. They should be located in the northwestern, eastern and southeastern parts of Tehran city.)

b. Observation equipment

The automatically controlled meteorological observation system should be introduced. The observation items are the pressure, wind direction and wind speed, relative humidity and solar radiation. The system should also have on-line devices.

c. Costs of the new equipment

6 sets of the automatic controlled meteorological observation system : US$180,000 (@US$30,000)

The costs are added up on the assumption that the data obtained at these points are concentrated and recorded in a main computer. The estimated cost only covers the equipment and does not cover setting up and inspection, etc..

② Upper meteorological observation making use of the existing steel tower

a. Observation sites which have an available steel tower : one point

b. Observation items : wind direction, wind speed, temperature difference between the two altitudes (one thermometer is equipped at 1.5m above the ground surface).

c. Costs of the new equipment

- Three sets of air meters = US$37,500 (@US$12,500)

  An air meter is a kind of anemometer designed to measure the speed of weak wind less than a few m/s.

- One set of temperature difference meter = US$12,500

  A temperature difference meter attached to the tower measures the temperature difference between the surface (1.5m) and its height.

- Data logger = US$2,500

  Obtained data will be recorded in the data logger temporarily and transferred to a computer through a floppy disk. The estimated cost only covers the equipment and does not cover setting up and inspection, etc..

7.2.2 Strengthening of meteorological observation in relation to air pollution

In order to derive the precise results of analysis and to make the appropriate comparison of meteorological data and the pollutant concentrations measured at many stations, the data quality needs to be improved by, for example, making observation accurately guided by a standardized manual. For this purpose, the followings are required:

① The trained engineers having skills and experiences should take charge of observation.

② Procedures of observation should be unified following a standardized manual.

(1) Training of engineers

Establishment of a training organization for meteorological observation under the supervision of IRIMO is recommended. Trainees should be assigned to learn meteorology, structure of instruments, and to practice inspection and maintenance of instrument. The trained specialist will lead observation planning and maintenance of instrument. Assistants should also participate in the basic training session. Furthermore, it is advisable to build up the system under which an engineer who finished the training course or who has corresponding skills will be given an authorized certificate after passing a qualifying examination and have his/her status recognized in the society.

The detailed suggestions for the training of engineers are shown below.

①The establishment of an organization for engineer training.

a. The places for training : The IRIMO facilities

b. Training subjects :

- General meteorology
- Meteorological observation methods
- Operation of meteorological observation instrument
- Statistics for the data processing

c. A full-time instructor in each subject will be assigned to the class.

② The department for supervision of meteorological observation facilities

a. The department should be established in IRIMO.

b. A full-time worker should be assigned to the department.

③ Establishment of organization for the qualifying examination

a. The organization will be established in IRIMO.

b. Three full-time workers will be assigned to the organization.

(Questions for the examinations will be made by an outside expert.)

(2) Drawing up the observation manual

IRIMO is supposed to make a meteorological observation manual for the purpose of improvement of data quality and standardization of observation. The manual should involve not only the standard procedure of observation, inspection and maintenance of instruments but also methods to make the database. The detailed suggestions for drawing up the observation manual are shown below.

a. Contents of the manual

- Instructions of meteorological observation
- Instructions of statistics for meteorological data processing

b. A staff member will be assigned for drawing up of each subject for a year.

(3) Data accumulation and data base

Environmental impact assessment requires meteorological data obtained at many stations as the basic materials for development of a simulation model. Therefore, the meteorological data observed and accumulated by each organization should be formatted in a common style and stored in the database in order to make the data easily accessible to the public. The detailed suggestions for making the database formatted in the common style are as follows:

a. Machines belonging to IRIMO are to be used for data processing.

b. Staff for making the data base

- Program writer — For about 5 months, one staff member to be engaged in operations of the current computer.
- Operator — One staff member, for about a month

7.3 Ambient air monitoring plan

7.3.1 Expansion of monitoring station network in MOT

In general, there are two kinds of monitoring stations: one is the general (air monitoring) station for measurement of pollutants in the ambient air, and the other is the road side (air monitoring) station, which is placed for measuring pollutants emitted from mobile sources at roadsides. More than a half of the available monitoring stations in Tehran are roadside stations. Therefore, such monitoring data may not be appropriate for assessment of the pollutants influence on environment and public health in Tehran.

The general stations should be placed where the measured concentration is not influenced by any particular sources and represents the ambient air in the surroundings. Therefore, careful site selection is essential. In order to grasp air pollution conditions in Tehran precisely, it would be recommend to set up a general monitoring station at about 50 km^2 intervals. In other words, 14 general monitoring stations are necessary to cover all over the city (The total area of Tehran: 700 km^2, 700 km^2／50 km^2 =14). Although it is desirable to establish 14 air monitoring stations, in line with actual situation, establishment of 11 air monitoring station in 20 districts is necessary as a first step (Total area of Tehran 20 districts: 560 km^2, 560 km^2／50 km^2 =11). The monitoring schedule should be made continuous and permanent to obtain qualified data for precise analysis.

Table 7.3.1-1 shows a list of the ambient air monitoring stations in Tehran with their details. Figure 7.3.1-1 also illustrates the locations of these stations in the Greater Tehran area. Currently, there are 3 general monitoring stations {Nikoughhadam St. (AQCC), Farhang Saraye Bahman(DOE), Haram(DOE)} and 6 roadside stations { Fatemi St./Valleye-asr(AQCC), Bazar Square(AQCC), Ostad Nejatollahee (DOE Bldg.), Azadi Square(DOE), Gholhak Area(DOE), Tajrish area(DOE)} in the city.

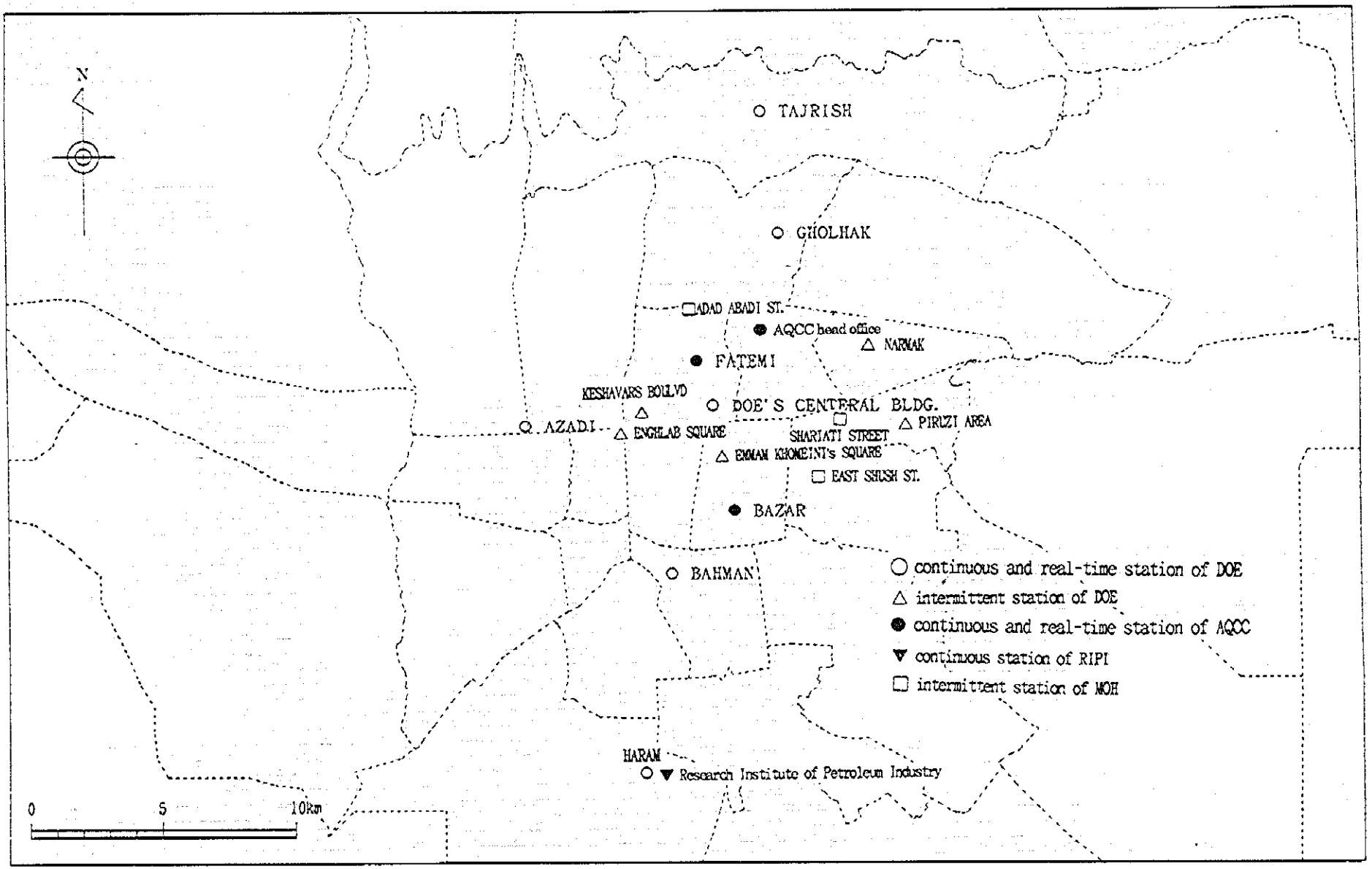


Fig. 7.3.1-1 Location of existing air pollution monitoring station (DOE, AQCC, MOH, RIPI)

Table 7.3.1-1 Air pollution monitoring station in Tehran (Location and detail information)

	Location of the station	Organization	Measured pollutants	Stating year	General or road
P/C	Fatemi St./Valleye-asr	AQCC	NO_X, SO_2, CO, O_3, THC, PM10	Sep. 1995	Roadside
P/C	Bazar Square	AQCC	NO_X, SO_2, CO, O_3, THC, PM10	Oct. 1995	Roadside
P/C	Nikoughhadam St. (AQCC Bldg.)	AQCC	NO_X, SO_2, CO, O_3, THC, NMHC	Jul. 1997	General
C	Mobile(movable station on truck)	AQCC	NO_X, SO_2, CO, O_3, THC, PM10	Oct. 1995	
P/C	Ostad Nejatollahee (DOE Bldg.)	DOE	NO_X,SO_2, CO, O_3,THC,NMHC, SPM	May 1993	Roadside
P/C	Azadi Square	DOE	NO_X,SO_2, CO, O_3,THC,NMHC, SPM	Jun. 1993	Roadside
P/C	Gholhak Area	DOE	NO_X,SO_2, CO, O_3,THC,NMHC, SPM	Jul. 1993	Roadside
P/C	Tajrish area	DOE	NO_X,SO_2, CO, THC,NMHC, SPM	Nov. 1994	Roadside
P/C	Farhang Saraye Bahman	DOE	NO_X,SO_2, CO, THC,NMHC, SPM	Dec. 1994	General
P/C	EmanKhomaini Mosque(Haram)	DOE	NO_X,SO_2, CO,THC,NMHC	(1995)	General
P/I	Piruzi Area	DOE	Intermittent SO_2, CO, Dust	1991	Roadside
P/I	Narmak Area	DOE	Intermittent SO_2, CO, Dust	1991	Roadside
P/I	Keshavars Boulevard	DOE	Intermittent SO_2, CO, Dust	1991	Roadside
P/I	Emam Khomani Square	DOE	SO_2,	?	Roadside
P/I	Enghelab square	DOE	NO_X,SO_2, CO	1991	Roadside
P/I	Shariati Street	MOH	Intermittent SO_2,TSP, Smoke	1973	Roadside
P/I	East Shoush street	MOH	Intermittent SO_2,TSP, Smoke	1976	Roadside
P/I	Seyed Jamato/Asad Abadi street	MOH	Intermittent SO_2,TSP, Smoke	1976	Roadside
P/C	Tehran Refinery	RIPI	NO_X,SO_2, CO, O_3, THC, Smoke	1969	General
P/I	NIOC Bldg.Courtyard/Hafez St.	NIOC(RIPI)	NO_X,SO_2, CO,THC, Smoke	1994	Roadside

Abbreviations AQCC: Air Quality Control Company DOE: Department of Environment

MOH: Ministry of Health RIPI: Research Institute of Petroleum Industry

NIOC: National Iranian Oil Company

P/C: Permanent, Continuous and Real-time measurement station

P/I: Permanent and intermittent measurement station

Notes: PM10 and SPM are mass concentration but based on different particle size separation, Dust and Smoke are relative concentration.

All of these continuous and real-time monitoring stations belong to DOE or the Municipality of Tehran (AQCC).

In addition to the existing facilities, 7 more ambient air monitoring stations should be established as a general station and so should be 3 more roadside monitoring stations. In consideration of the results of the simplified measurement by the JICA Study team, the recommended general station sites are shown on the map in Fig.7.3.1-2.

Because of the constraint in funding, measuring all the pollutants in all the stations may not be necessary. For example, ozone is not worth measuring at roadside stations, where the very high concentration of NO is usually observed, because NO readily reacts with O_3. Examples of equipment for a general air pollution monitoring station (permanent , continuous and real-time measurement) are shown in Table 7.3.1-2.

Table 7.3.1-2 The example of equipment list for a general air pollution monitoring station

Major Equipment	Pollutant to be measured	Detector Type	Standard Gas	Additional Equipment
Ambient SO_2 Monitor	SO_2	UV fluorescence	SO_2	Regulator
Ambient NOx Monitor	NOx(NO,NO_2)	Chemiluminescence	NO	Regulator
Ambient CO Monitor	CO	Non-dispersive infrared	CO	Regulator
Ambient O_3 Monitor	O_3	Ultraviolet absorption		Regulator, O_3 Generator
Ambient HC Monitor	THC(CH_4, NMHC)	Flame Ionization	CH_4, NMHC	H2Generator, Regulator
Particulate Monitor	SPM(or PM10)	β ray absorption		Regulator
Processing computer		Pentium processor		Display, Printer
Zero Gas Generator		With mass flow controller		Teflon Tubes, Connectors
Elec. Power Stabilizer				With UPS

Notes: PM10 and SPM are mass concentration but based on different particle size separation

NMHC: Non-methane hydrocarbons

Total cost of one ambient air monitoring stations is about 300.000 US$

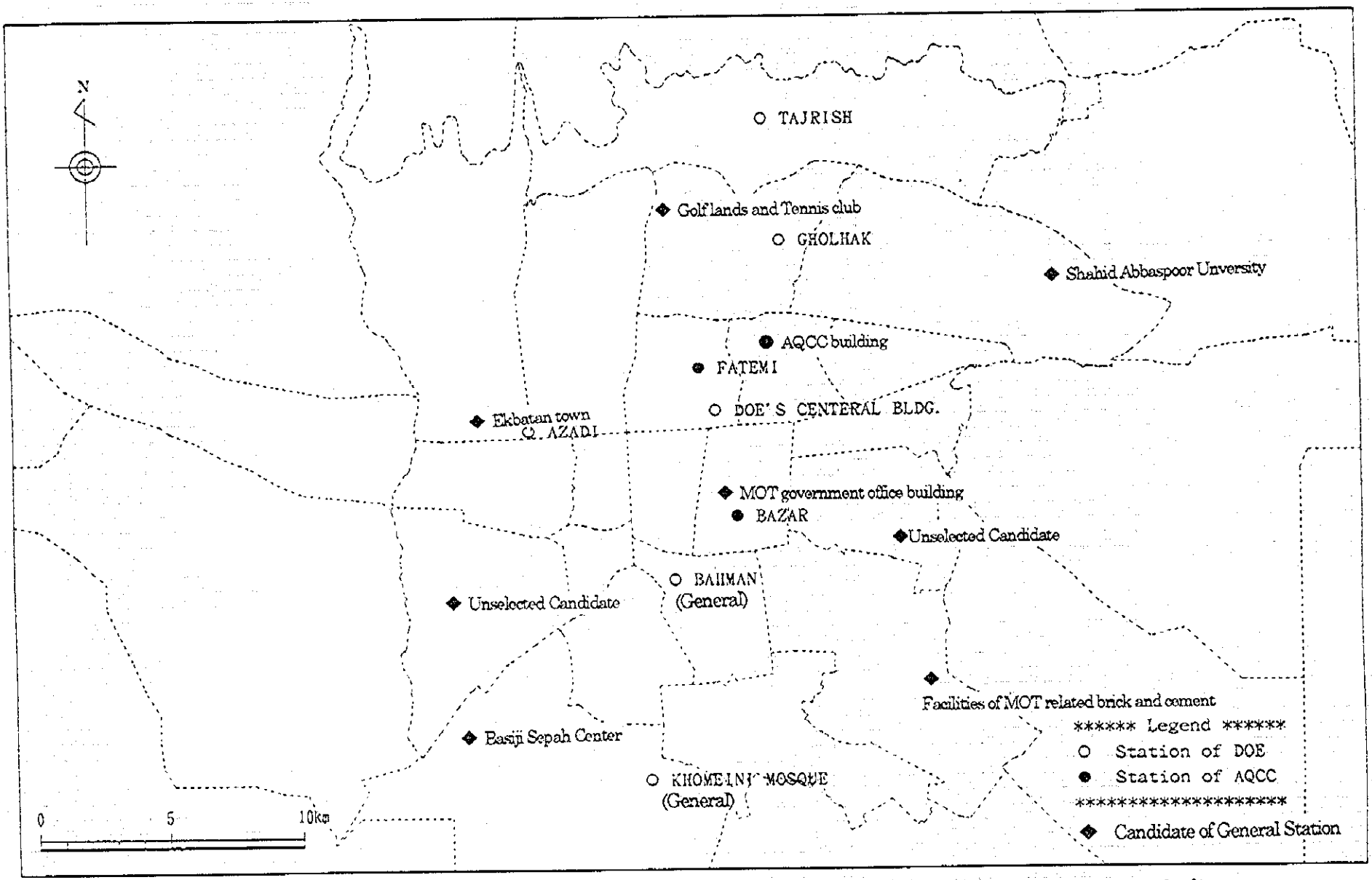


Fig.7.3.1-2 Location of existing station and future candidate of general monitoring station for air pollution (in draft)

7.3.2 Establishment of environmental research institute

In view of the present activities for improvement of air quality in Tehran, a national environmental research institute should be established for strengthening of monitoring functions in Iran. The national environmental research institute under DOE, however, would not achieve its objectives without appropriate systems and capable staff. Alternatively, it may be desirable to establish a municipal environmental research institute under supervision of AQCC, to which research oriented duties of TTTO, TTCC and TCTTS will be assigned. It is advised to found a technological training center for air pollution as an organization attached to the research institute to give opportunity for university graduates with B.Sc. or M.Sc. to receive practical training. And then activities for disposal of wastewater and municipal solid waste and preservation of flora and fauna will be added to its training curriculum stepwise. An example of the organization chart of the environmental research institute is shown in Fig. 7.3.2-1.

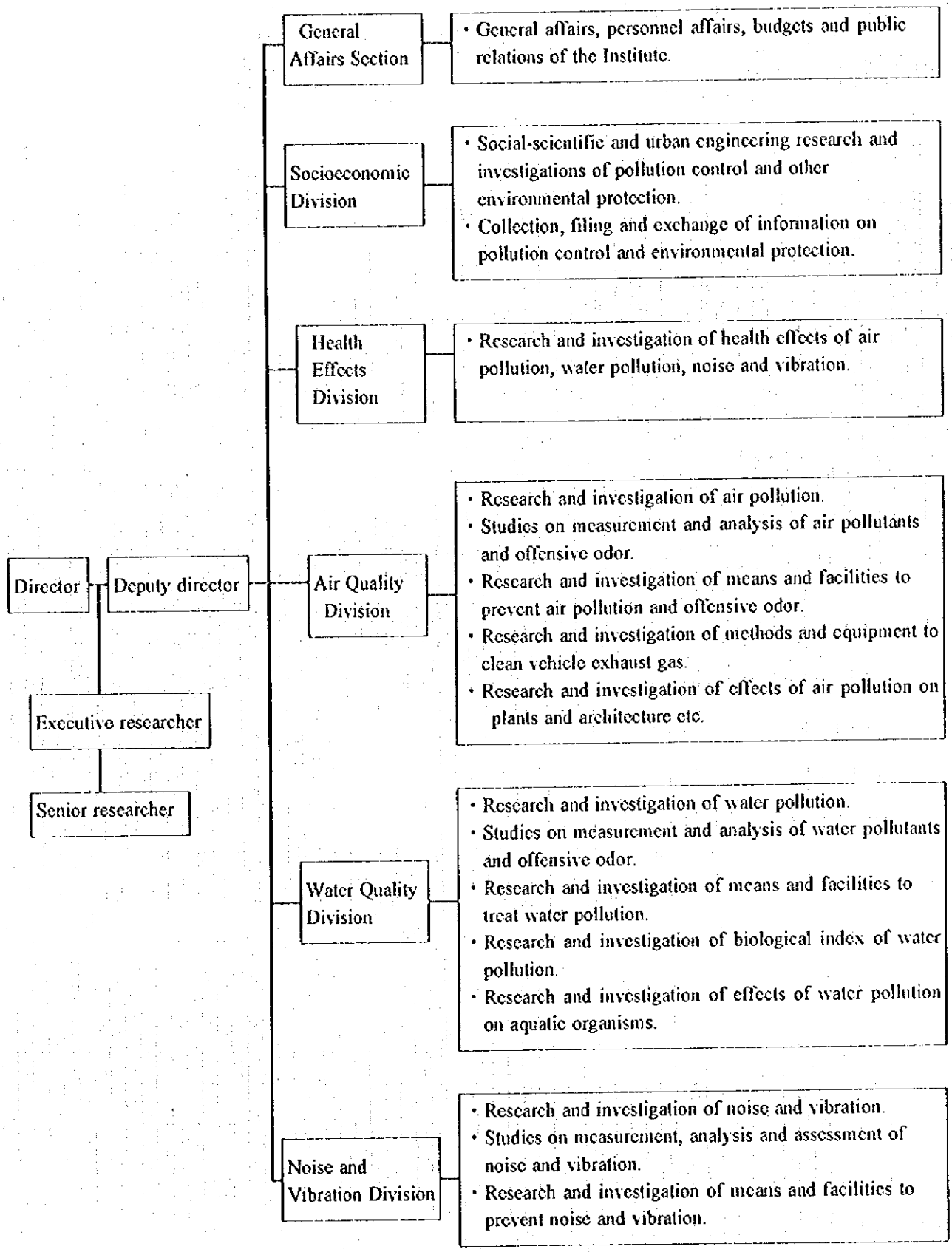


Fig.7.3.2-1 An example of organization chart for environmental research institute