Chapter 6

Chapter 6 Framework of Air Pollution Monitoring System in the Model City

6.1 Necessity of Monitoring system

(1) The Conducted Results from the Study

The Air Quality Monitoring (AQM) system has not existed in Skopje before commencement of the Study, and the samples taken everyday are analyzed once a week. Moreover, only the RHI had the data on the weather such as the wind direction and speed, temperature and humidity, but it was insufficient system for studying the actual conditions of air pollution. Furthermore, it took too much time to get results, so that the measures for emergency did not function well.

The AQM system in Skopje seems to have worked well and to have supplied data of great use on air pollution, for around a year.

In addition, the accumulation and analysis of monitoring data make it possible to clarify the phenomenon of air pollution such as the stagnation episode from December 1998 to January 1999 which have occurred cyclically, and to help the prediction of unusual air pollution and take the necessary actions on the scientific basis in future.

(2) Present Condition of Air Pollution

The data from AQM stations for about a year, suggest the air pollution problem in the country is focused on two points:

The first one is the occurrence of photochemical smog in summer. The second one is heavy concentrations of pollution combined with SO_2 and SPM in winter. The photochemical smog in summer results from the exhaust gas emitted from old automobiles without emission control, and air pollution in winter is caused by emission from factories, enterprises and heating facilities, and weather conditions.

There are various measures against air pollution, but the serious stagnation in winter should be prioritized.

(3) Importance of Monitoring and its Difficulties

The importance of continuous monitoring of air pollution is to obtain basic data and information for the followings:

- Understanding of the level of air pollution and judging whether environmental standards are cleared or not

- Countermeasures in an emergency case
- Prevention of damage to human body

From the results obtained though the Study, the following difficulties are pointed out. In accordance with the "1996 Law on Environment and Nature Protection and Promotion", the MOE acts as executive agency for environmental management.

a) Organizations which partially monitor the air pollution are the IPH and the RHI and it is difficult to integrate the monitoring data on an administrative basis.
b) It takes time to find out about the pollution level because of the time taken 24-hour sampling and the subsequent analysis of sample in laboratory. Quick counter-measures in an emergency case can not be taken.
c) Judgment of short-term pollution can not be made because of no hourly environmental standards.
d) It was observed that some error factors were included in the existing measuring method based on the results of cross-check.

(4) Necessity of Further Monitoring

Due to installation of AQM system at four stations and one set of mobile monitoring system in the course of the Study, urgently required monitoring systems were mostly set up in the model city. Moreover, in order to solve problems expect c) mentioned above, it is required to provide further monitoring system to measure air pollution in model city considering the results of the Study as well as environmental administration. Concrete items required are as follows.

- To monitor ambient air quality in residential areas, in north and east parts of Skopje, excluded from AQM network.
- To monitor exhaust gas from stationary sources continuously which have large air pollution load in order to take a measure of fuel conversion to low sulfur fuel or cutback in operation of plants.
- To monitor stationary source as well as supplementary ambient air quality using mobile monitoring system.
- To inspect auto-exhaust gas in order to comprehend the actual condition of it which is not monitored at present.
- To establish APMC in order to send all monitored data into the MOE and conduct maintenance and management. To dispose required personnel at the same time.
- To replace the superannuated equipment in the Institute of Environment Zerezala (IEZ), for improve of analytical capability of samples related to air pollution.

6.2 Equipment and Materials Planning

Air pollution monitoring station is categorized into AQM station, road side monitoring station for vehicular exhaust gas, CEM station and its supporting mobile monitoring station (these four types can be equipped with automatic continuous monitoring instruments), and various types of sampler. Monitoring with such samplers requires chemical analysis and the laboratory. Enormous amount of data is obtained through monitoring and it is therefore necessary to introduce computer for the processing and storage of data.

There have been drastic developments in existing monitoring system including software for the past decade due to the rapid development in the hardware of monitoring instruments and personal computer and in the communication tools. In order to reduce the management cost of monitoring stations, it is necessary to apply such up-to-date technology as mentioned above to the present and future monitoring system in Macedonia. Overall concept of advanced monitoring and software system is shown in Figure 6.1.

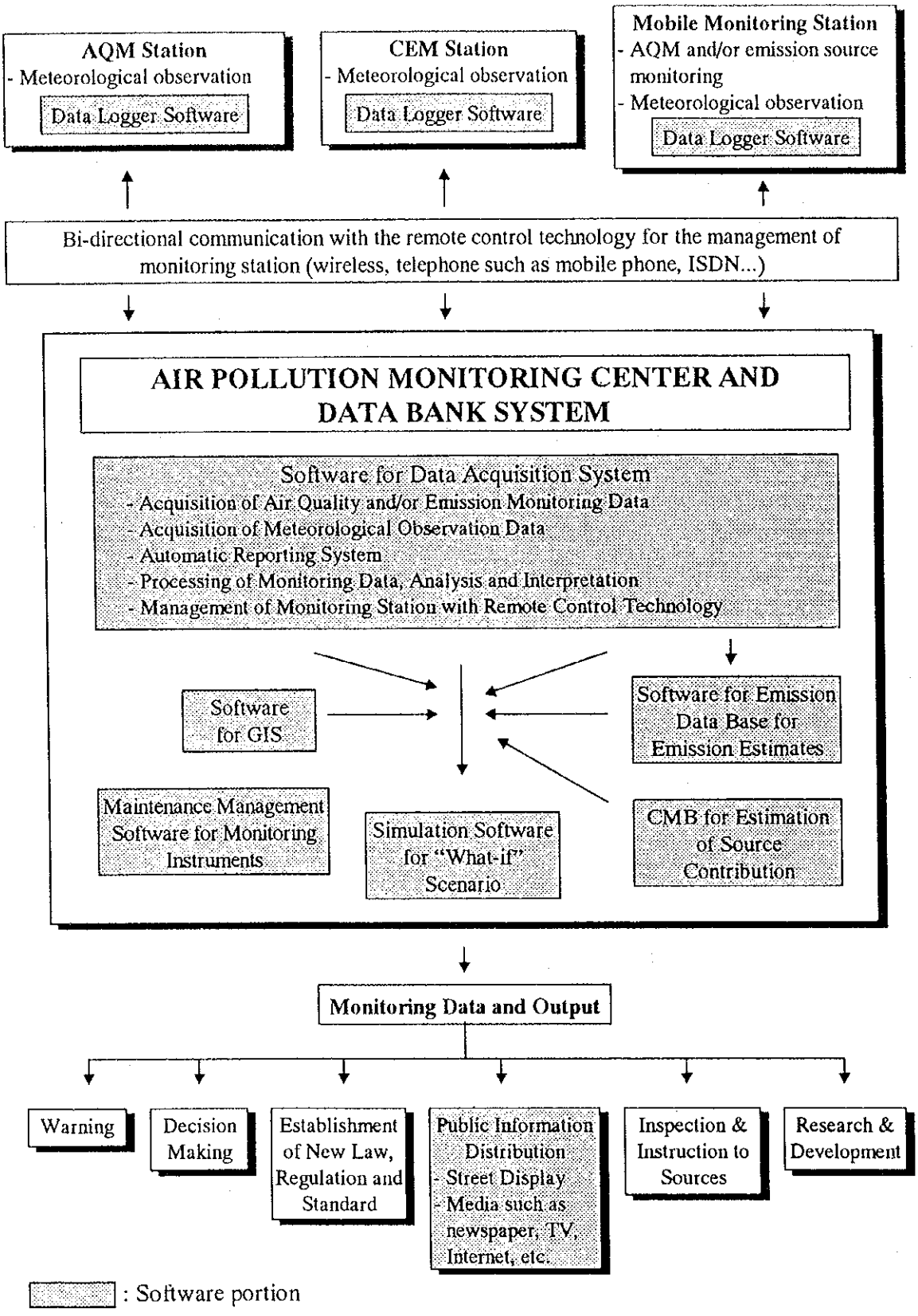


Figure 6.1 Overall Concept of Advanced Monitoring and Software System

6.2.1 Selection of Equipment and Materials

(1) Considerations for Selection of Equipment and Materials

As a result of procurement of equipment and materials necessary for the Study and the Site Works throughout the four seasons, various results and findings were obtained. Considerations for future planning were also identified; for example, the necessity of consideration of the meteorological characteristics for selection of equipment and materials, etc..

1) Consideration of Temperature for Container

The temperature range at Skopje has a variation of 60℃; minus 20℃ in winter and often exceeds 40℃ in summer. It means that careful consideration must be given to the construction of the container. It is necessary to strengthen the container insulation (thickness: 100 mm or more).

2) Air Conditioner of Container

When the air conditioner fails to operate during the daytime in summer, the interior temperature in the container rises far above the permissible level for the monitoring equipment due to heat generation of the equipment itself and intense solar radiation. Such an excessive temperature rise may result in the failure to obtain the monitoring data and the breakdown of the expensive hardware.
Though the strengthened insulation of the container may delay the temperature rise effectively, it is meaningless without taking a quick action. It is therefore desirable to provide two air conditioners in the AQM station.

3) Selection of Wind Vane Anemometer

Characteristically, the wind speed in winter is extremely low in Skopje which in turn causes severe air pollution. To enable air pollution analysis, it is appropriate to select an ultrasonic wind-vane anemometer which has no driven part and can monitor the breeze accurately.
Consideration should also be given to the low temperature and high humidity in winter. Since freezing on the sensor block of this ultrasonic wind-vane anemometer causes monitoring errors, a type with a built-in heater may be necessary. If a normal breeze wind-vane anemometer is used, measurements may become impossible due to freezing at the drive point.

4) Considerations Concerning Monitoring Range

According to the result of the Study, the air quality concentration undergoes substantial fluctuations according to the time, the day and the season. It is essential that the monitoring equipment has a range sufficiently compatible with large concentration changes.

5) Selection of SPM Meter

Typical monitoring of the SPM includes TEOM and β-ray absorption. Though their detection methods differ, both methods are based on measurement of the SPM mass collected on the filter. This means that the effect of humidity on the filter is one of the probable error factors.
In the case of the TEOM method, the sampling tube and sensor are heated to cope with the effect of humidity. It is not yet confirmed that such heating is sufficiently effective in the low-temperature and high-humidity condition in winter. It is essential to prepare the specification after a thorough study of the SPM meter data.

6) Self-diagnosis and Remote Control Function of the Monitoring Equipment

Although approximately 20 years have passed since the first delivery of the monitoring equipment, its failure rate remains high. In other words, a monitoring equipment with a self-diagnosis function is advantageous for preventing failures before they occur. The personnel and cost required for the maintenance of the AQM system is not insignificant for the MOE, which means that a reduction of the costs is desirable. This can be achieved by controlling the air pollution monitoring station in such a manner that the central station is provided with the remote control function, in addition to data processing, for performing the self-diagnosis and calibration of the monitoring equipment.

(2) Considerations for Development of Equipment and Materials Plan

Proper consideration must be given to the following matters during development of the equipment and materials plan:

- The quantity and location of the air pollution monitoring stations must be determined taking into consideration the monitoring items, so that the maximum effect can be achieved within the limited budget.
- The monitoring equipment and materials must have the monitored items and specifications in compliance with the EU legal system.

6.2.2 Planning on AQM System

(1) Characteristics and Representativeness of Each Monitoring Station

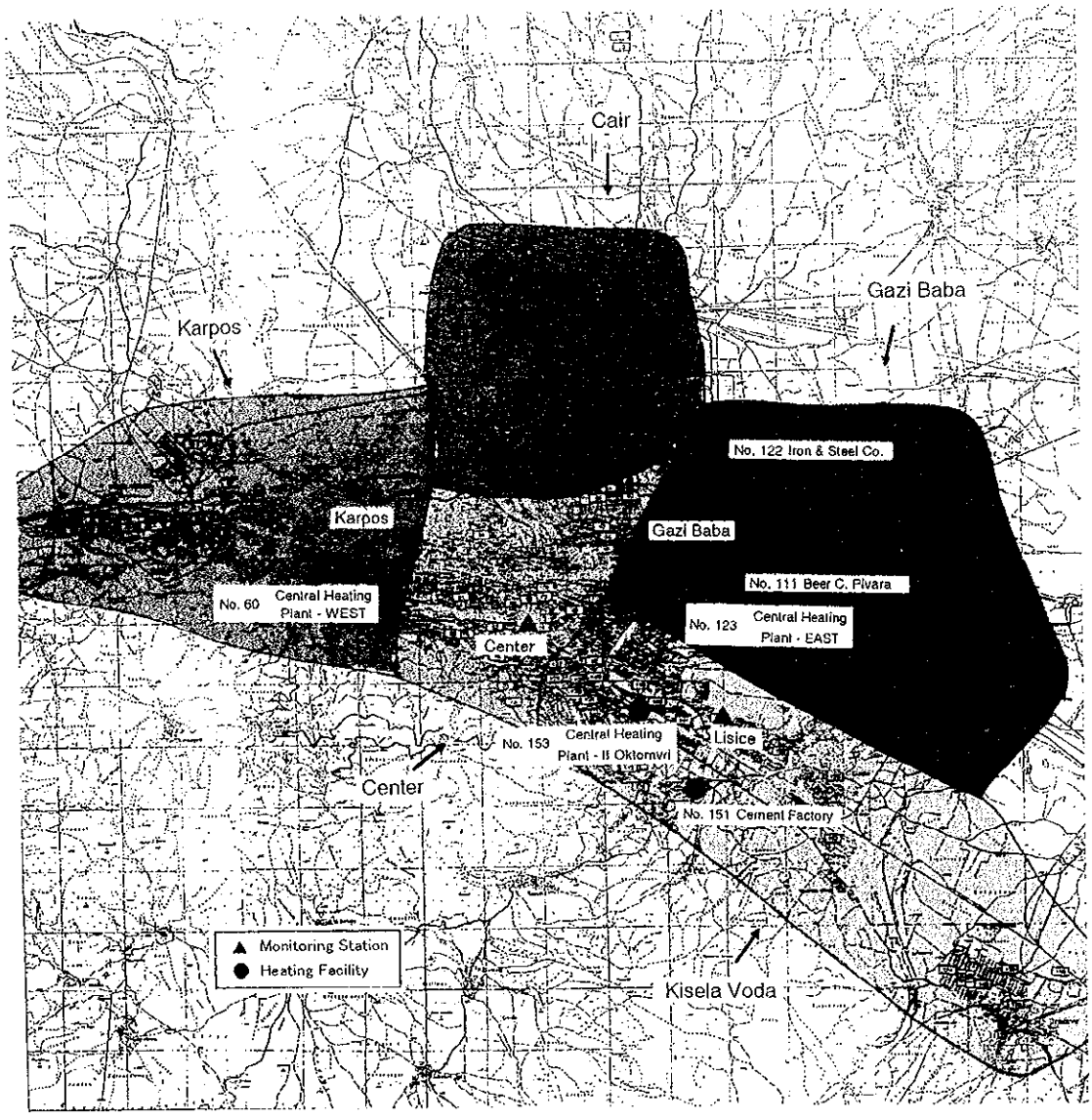
Based on the extensive field survey of concentration distribution pattern of pollutants with the simplified-sampler in Skopje which became a model city, four monitoring points were selected and automatic continuous monitoring instruments were installed. The characteristics of those four monitoring stations are as follows and described in detail in Chapter 3.

- Large emission source is located near this point but influence from local emission source is small
- Medium- and small-sized emission source scattered point in the center of Skopje
- Automobile exhaust gas impacting point
- Intermediate point between industrial area and newly developed residential area

(2) Planning on Number of Monitoring Station and Equipment and Materials

1) Consideration of Effective Monitoring Stationing

Figure 6.2 shows location of the four AQM stations and major stationary emission sources by the District comprising of five prepared based on the questionnaire survey to the factories and field survey in the model city.
According to the Figure, those four monitoring points mentioned above are relatively located in the center of Skopje and do not cover the northern part of city (green colored area) where is mainly residential area. The city, especially residential area is extending to the eastern part of city (red colored area) where construction of residence is under way and is not covered with the present AQM stations. And also the present AQM stations belong to the industrialized or semi-industrialized area. In case of stagnation episode, it is also necessary to monitor the concentration level of air pollution in the residential areas because serious damage to human body is concerned. It is therefore recommended that two more AQM stations be set up in the northern and eastern part of city where are the residential areas.
Further, as judgment criteria for the announcement of alarm at the time of appearance of high concentration of air pollution, it is stipulated that monitoring values at the neighboring monitoring stations covering 4 x 4 km area for each station exceed the standards. In case the model city is divided into areas, whole city area, especially northern and eastern areas of the city can not be covered with the present AQM system. It is therefore desirable that the expansion of monitoring system in the model city includes the residential areas in the north and east of Skopje.



▲: AQM Station

●: Major Stationary Emission Source

Figure 6.2 Type and Location of Major Stationary Sources and its Emission Intensity by the District

2) Monitoring Equipment and Materials

The monitoring parameters of additional two AQM stations are the same as those of the present monitoring stations. But it was observed in the course of the filed survey that net radiation meter was needed for the evaluation of atmospheric stability in addition to the present equipment items. The detailed equipment list is shown in Table 6.1.

Table 6.1 List of Equipment and Materials for AQM System

No.	Name of Equipment	Q'ty
1	Fluorescent SO_2 Analyzer	2
2	Chemiluminescence NOx Analyzer	2
3	NDIR CO Analyzer	2
4	UV O_3 Analyzer	2
5	Suspended Particulate Matter Analyzer	2
6	Calibrator	2
7	Zero Air Generator	2
8	Standard Gas (NO, CO) 10 ℓ	4
9	Regulator (NO, CO)	4
10	Recorder (12 dot)	2
11	Sample Manifold with Heater	2
12	Wind Direction & Speed Meter	2
13	Thermometer / Hygrometer	2
14	Solar Radiation Meter	2
15	Net Radiation Meter	2
16	Meteorological Data Translator	2
17	Data Logger with Telemeter System	2
18	Automatic Voltage Stabilizer 8 kVA, single phase	2
19	Automatic Delayed Restoration Device from Power Failure	2
20	Rack for Analyzer	2
21	High Volume Sampler (outdoor)	2
22	Shelter with Air Conditioner	2
23	UPS (30 minutes Back Up) 5 kVA	2
24	Public Information System	1
25	Maintenance Car	1
26	Installation and Start Up	2
27	Training	2
28	Transportation and Insurance	2
29	Foundation Work for Shelter	2
30	Fence Works for Monitoring Stations	2

6.2.3 Planning on CEM System

(1) Monitoring Method

Stationary emission source monitoring is categorized into the following two methods:

1) Spot Measurement for a Few Hours

Generally speaking, the spot measurement is still the leading method even now and it is applied widely to the factories from large- to small-scale. It is however difficult to measure the emission in proportion to the load fluctuation.

2) CEM

Large-scale stationary emission source with a large amount of burden to the environment tends to install the CEM instruments.

(2) Stationary Emission Source Monitoring

Emission has been monitored in Macedonia with the conventional portable-type exhaust gas measuring instruments. One set of mobile monitoring car stationed in the model city makes it possible to monitor the emission more accurately and frequently. The major pollutants in the model city are SO_2 and SPM. It was observed that the high concentration exceeding the criteria for the alarm announcement appeared during heating season. In order to monitor the amount of emission of pollutants from the stationary emission sources in an emergency case such as the serious stagnation episode and check whether the emission standards are cleared or not, it is recommended that three sets of CEM instruments be installed to the large-scale emission sources in the model city as mentioned below.

(3) Stationary Emission Source and its Parameters to be Monitored in the Model City

Major stationary emission sources and its parameters to be monitored automatically and continuously in the model city are shown in Table 6.2.

Monitoring data are transmitted to the APMC via wireless telemetric system automatically and it is necessary to calibrate the monitoring instruments using standard gases from the APMC with the remote control technology.

Table 6.2 Major Stationary Emission Sources and its Parameters to be Monitored in the Model City

No.	Name of Factory	Type of Combustion	Type of Fuel	Parameter
60	Heating Plant WEST	Boiler 170 W	Heavy oil	Dust, SO_2, NOx and CO
123	Heating Plant EAST	Boiler 294 MW	Heavy oil	Dust, SO_2, NOx and CO
151a	USJE Prvomajiska bb	Cement Kiln	Heavy oil & coal	Dust, SO_2 and NOx

As one of countermeasures against air pollution during the first stage or within five years described in Section 6.5 p.6-38, a plan of fuel conversion into natural gas for the heating plant is prepared. In case the plan is certainly realized, it is not necessary to monitor the heating plants listed above.

(4) Monitoring Equipment and Materials Planning

The details of equipment and materials to be installed for CEM are shown in Table 6.3.

Table 6.3 List of Equipment and Materials for CEM System

No.	Name of Equipment	Q'ty
1	Multi-Gas Analyzing System (SO_2, NOx, CO, O_2) Outdoor	3
2	Opacity Meter	3
3	Data Logger with Telemeter System	3
4	Standard Gas (SO_2, NO, CO, N_2, O_2) 10 ℓ	15
5	Regulator (SO_2, NO, CO, N_2, O_2)	15
6	Installation and Start Up	3
7	Training	3
8	Transportation and Insurance	3

6.2.4 Planning on Mobile Monitoring System

In order to monitor the stationary emission source in the model city, a set of mobile monitoring car which is able to measure SO_2, NOx, CO, dust and velocity of exhaust gas, was provided for Macedonia. There are however more than 500 combustion facilities only in Skopje and also some large stationary emission sources are scattered in Macedonia. It is therefore impossible to monitor all the stationary emission sources with one mobile monitoring car. In order to supplement the insufficient monitoring of stationary emission source in the model city and other cities in Macedonia as well as AQM in uncovered area with the fixed station, it is necessary to station another mobile monitoring car in the model city. The equipment and materials for mobile monitoring

are the same as the present mobile monitoring car. The list is summarized in Table 6.4.

6.2.5 Planning on Auto-exhaust Gas Inspection System

The automobile inspection system exists as an institution but is not enforced actually because no inspection equipment and materials for automobile exhaust gas is equipped. At the initial stage of equipment and materials planning on automobile exhaust gas inspection system, such costly facility and equipment as chassis dynamometer and Constant Volume Sampler (CVS) which is able to measure the concentration of exhaust gas by driving mode should not be introduced into the inspection system. In order to grasp the present situation of mobile emission, it is recommended that a set of equipment and materials for the inspection of automobile exhaust gas be introduced to APMC in the model city. The equipment and materials to be needed for the inspection are shown in Table 6.5.

Table 6.4 List of Equipment and Materials for Mobile Monitoring System

No.	Name of Equipment	Q'ty
1	Fluorescent SO_2 Analyzer	1
2	Chemiluminescence NOx Analyzer	1
3	NDIR CO Analyzer	1
4	UV O_3 Analyzer	1
5	Suspended Particulate Matter Analyzer	1
6	Dilution Unit with O_2 Sensor & Zero Air Generator	1
7	Automatic Isokinetic Dust Sampler	1
8	Mass Flow Calibrator	1
9	Zero Air Generator	1
10	Standard Gas (SO_2, NO (H&L), CO(H &L), O_2, N_2) 10 ℓ	7
11	Regulator (SO_2, NO (H&L), CO(H &L), O_2, N_2)	7
12	Recorder (12 dot)	1
13	Data Logger with UPS	1
14	Impactor for Flue Gas	1
15	Automatic Voltage Stabilizer 10 kVA, single phase	1
16	Monitoring Car (Truck chassis)	1
17	Monitoring Car (Shelter on truck)	1
18	Rack for Analyzer	1
19	Wind Direction & Speed Meter	1
20	Thermometer / Hygrometer	1
21	Meteorological Data Processor	1
22	Sampler ; High Volume Sampler (outdoor)	1
23	Sample Manifold	1
24	Tool Set	1
25	Telescopic Pole for Meteorological Meters	1
26	Installation and Start Up	1
27	Training	1
28	Transportation and Insurance	1

Table 6.5 List of Equipment and Materials for Auto-exhaust Gas Inspection System

No.	Name of Equipment	Q'ty
1	Exhaust Gas Analyzer (CO, CO_2, HC, O_2)	1
2	Diesel Smoke Meter (Filter paper reflection type)	1
3	Air Compressor for Diesel Smoke Meter	1
4	Standard Gas for Exhaust Gas Analyzer	3
5	Regulator	3
6	Mobil Car with Air Conditioner and Power Generator	1
7	Tool Set	1
8	Training	1
9	Transportation and Insurance	1
10	Engineering	1

6.2.6 Planning on Data Logging, Acquisition and Processing

It is necessary to introduce computer hardware and software at monitoring station for data logging and the APMC for the acquisition, processing and exporting of air pollution monitoring data in the model city.

(1) Computer Hardware

Computer hardware and its peripherals at the APMC and monitoring station comprise of the followings depending on the purpose of application:

1) AQM

Hardware for continuous monitoring of data sent from AQM stations via wireless telemetric system; Personal Computer (PC) and Printer

2) CEM

Hardware for continuous monitoring of data sent from CEM stations via wireless telemetric system; PC and Printer

3) Data Management

Hardware for integrated data management related to all the air pollution information; Server Computer, PC and Printer

4) Data Input and Output

Hardware for input, output and validation of relevant data; PC what is called shadow server and Printer

5) Other Supporting Hardware

Hardware for input and output of image and drawing; Image Scanner and XY Plotter

(2) Computer Software

The software which was provided for Macedonia under the Study as well as will be recommended for its expansion of monitoring system in the model city and other cities in Macedonia is summarized in Table 6.6.

Table 6.6 Present Software and Software Recommended for Expansion in APMC

Software	Present	APMC
Data Logger	○	
Data Acquisition System	○	
Geographical Information System (GIS)	○	*
Maintenance Management of Monitoring Instruments		○
Emission Database		○
Chemical Mass Balance (CMB)	○	
Simulation Model (Air Dispersion)	○	
Public Information Distribution System	○	*

* : Considering the development in technology in future, further expansion or upgrade is recommended.

1) Data Logger Software

The main function of the data logger software is to provide a very detailed process management of monitoring. The monitoring stations have their own monitoring instruments installed with calibration unit and local data logger. The data logger software in Macedonia is PC-based, equipped with Uninterrupted Power Supply (UPS) and communication tools like the modem and antenna. The logger has a process interface for receiving values from instruments and controlling of instruments. This interface consists of RS 232 board with eight channels and Digital I/O board. Detailed interface and features of data logger software are summarized below. The overview of monitoring station is shown in Figure 6.3.

a) RS 232 Board with Eight Channels

All monitoring instruments provided are connected to the board by RS 232 lines. Even SPM monitor and meteorology sensors also use RS 232 only. RS 232 provides flexible interface for data acquisition, remote diagnosis and status analysis. The connected UPS through RS 232 provides an electrical shock-free operation of logger, however RS 232 line provides the automatic shutdown and start-up.

b) Digital I/O Board

As the monitoring stations have calibration unit, the logger can provide calibration control using digital inputs and outputs. The digital I/O board meets the requirements of calibration unit and electrical interface.
All analyzers are attached through RS 232 up to eight channels. The flexible serial protocols make it possible to get both instantaneous and average values. Even for the remote diagnostic functions, RS 232 opens the analyzer.

For example, internal zero span module is equipped with SO_2 analyzer and the logger can therefore control the calibration of SO_2 unit. The control of SO_2 including calibration can be performed manually, automatically or remotely.

Digital I/O card has 16 input and 16 output channels being optically isolated. These channels are suitable for contact closures of analyzers. For the calibration unit, there is only the digital I/O interface which controls the calibration of zero/span gas inlet. Using the above interface, data logger software provides all logger functions at the monitoring station. The main concept of the software is to provide a very detailed process management of monitoring. The software is also suitable for air quality and emission data logging. It is recommended that data logger software be operated using the operating system of MS Windows. Under the application of Windows, the future expansion of data logger software is much easier than that for MS-DOS and more Windows program on the same computer can be run.

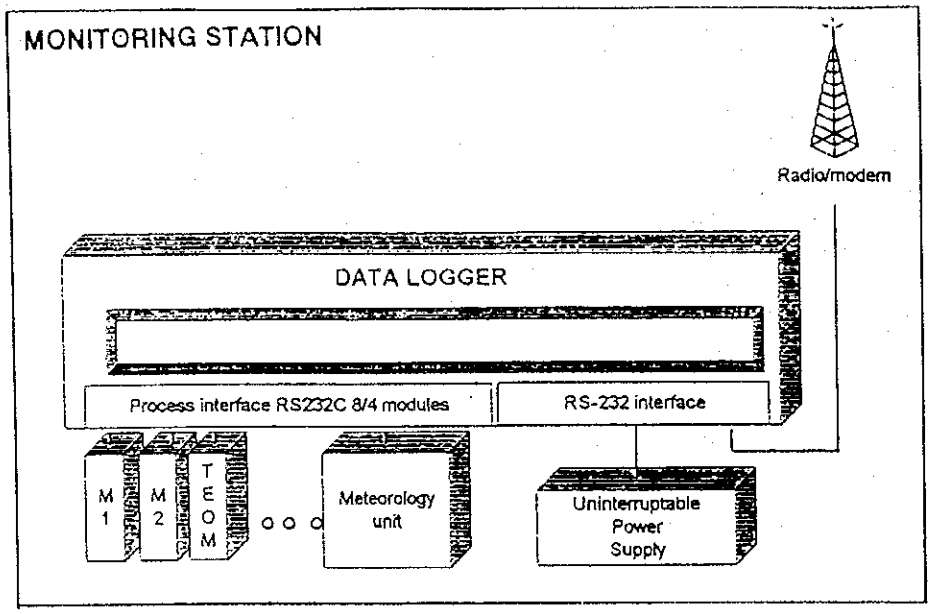


Figure 6.3 Overview of Monitoring Station

2) Data Acquisition Software

Data acquisition software at the central station (APMC) in Macedonia has the following three main functions for the management of monitoring stations through the telemetric system.

- Data acquisition
- Data processing
- Data transmission to the public information distribution system

a) Data Acquisition

One of the most important roles of data acquisition software is the continuous data acquisition from each monitoring station and the data management. The central station starts the polling of monitoring station randomly or in an order configured in advance. This software controls the communication between the central station and monitoring stations directly and/or through Local Area Network (LAN) if the necessary software and networking are applied. The software supports the communication line including the last data time and data communication time by clicking on Geographic Information System (GIS). It also controls the current status of monitoring station including electricity and automatic switch on/off functions.

b) Data Processing

The other important role of data acquisition software is data processing. The database is the source of meteorology and air pollution statistics, daily, monthly and annual reports, trends, limit and air quality evaluations. And also various functions related to data editing, data saving and built-in help are available. The results of data processing can be exported to the other spread sheet programs like MS-EXCEL. The competent authority in many countries regulates the format of the report. In case the format of the report is also regulated by the MOE, it is recommended that the automatic reporting function in the data acquisition software be configured to save time and man power in future.

3) Maintenance Management Software for Monitoring Instruments

The maintenance management software for monitoring instruments is described in detail in Section 6.4.4 (p.6-37).

4) Software for Emission Database

The Study is mainly focused on the establishment of AQM system and therefore the software for emission database is not included. In order to understand and to reduce the amount of emission from the various emission sources such as stationary, mobile and area sources, software for emission database will be very important in the future. One of the examples of software for emission database is described below.

a) Storage of Source Data

i) Stationary Emission Source

- General information such as the name of the company, address, contact person, date of entry, etc..
- Static information such as stack height, inner and outer diameter of the stack, exhaust gas temperature, coordinates and influence of any nearby buildings.
- Dynamic information directly controlling the emission, such as formulae that describe the emission as a function of outdoor temperature, or as a function of day type and hour, etc.. Formulae are defined in the form of time and temperature variation tables. The emission variations defined in the formula are interpreted in the two principal ways: as a consequence of linking a substance, a substance group or a fuel to a formula. A formula connected to a source type where the emission is described in terms of a fuel also includes a description of the variation of exhaust gas velocity in terms of the fuel consumption.

ii) Area Emission Sources

Area emission source data are stored in the same way as stationary emission sources except that no static information is used. The emission is assumed to be evenly distributed over the whole area source at a height of 2m above the ground. All area emission sources are rectangular.

iii) Mobile Emission Sources

Mobile emission source data are stored in the database as vector chains. Each road source must be linked to a particular road type, which describes the yearly, monthly and daily traffic pattern, speed restrictions and the vehicles that use the road.

b) Emission Specification

i) Stationary and Area Emission Source

The emission levels for stationary and area emission sources may be given in two different ways; specifying a yearly average (in tons/year) of substance or substances group, and specifying a maximum effect (in MW) as a consequence of a fuel combustion process.

ii) Mobile Emission Sources

Mobile emission sources are used to describe traffic emissions, consequently traffic intensity will be the quantitative measure for each individual road source (the unit chosen is the yearly average of the number of vehicles per day). All roads must be

linked to a road type, which consists of tables describing the composition of different vehicles running on a particular road, and also the time variation of the traffic intensity throughout the year and over the day.

c) Output from Emission Database

i) Normal Output

Typically the sources found by searching in the emission database are displayed on the map together with the emission figure for each source. The total emission figure is then presented in g/sec. together with the equivalent of this value in tons/year.

ii) Grid Output

Output can also be presented on the map as a colored grid. Interval limits can be defined by the operator and different color assigned to each interval. The map is split up into grid squares - the size of these being chosen by the operator - and then total emission within each square is calculated. The grid square is then colored according to which interval the emission figure falls into.

iii) Report Output

The report function can be used to extract information from the emission database and present it as a written description displayed in a separate window, stored as a file or sent to the printer. The operator can display selected static data such as source locations, or dynamic information such as the levels of emissions in a specific area for particular time and temperature conditions.

5) Simulation Software

Description of simulation software and receptor modeling is summarized in Chapter 5.

- Display of monitoring data in chart formats on the public information distribution system. The collected data are sent to the display monitor every hour. The data are refreshed on the screen of information terminal. Values are presented in both measured units and in percentile depending on the given standard. Local storage of data is also important in the presentation of daily or monthly trends.

- Additional public information such as announcements from authority is the second module of public information distribution system. Varying daily, weekly and monthly information is displayed in a way of slide organized mode presenting the work of the environmental organization. These help to enhance the public awareness. All functions are configured through radio waves or telephone line. The status checking from the central station is possible as well as the data communication to the public information terminal. If any trouble occurs in automatic data transmission, the system transmits the data to the central station from the time when the last data communication has been made.

b) Internet Based Information Distribution System

Besides the conventional media such as newspaper and TV, monitoring data can be distributed to the general public, media and decision-makers via Internet. It is recommended that Internet based information distribution system also be introduced in the future. When logged on the Internet, anybody is able to access and receive information about air quality, emission, regular and special reports, etc..
This system allows users to select the kinds of information distributed. The information is organized in a strict hierarchy and can be found in different folders covering, for example, the following main areas:

- General information about the distributor's organization, e-mail address, etc..
- News and events about ongoing activities related to the distributor's organization.
- Forecasts and reports about studies and projects, etc..
- Air quality information from the nationwide monitoring stations.

The public can choose to view such information mentioned above from the different regions in nearly real time by clicking on the map or list boxes. Meteorological information is also available. Most of the information is presented as graphs and the advanced users can download basic data for further analysis.

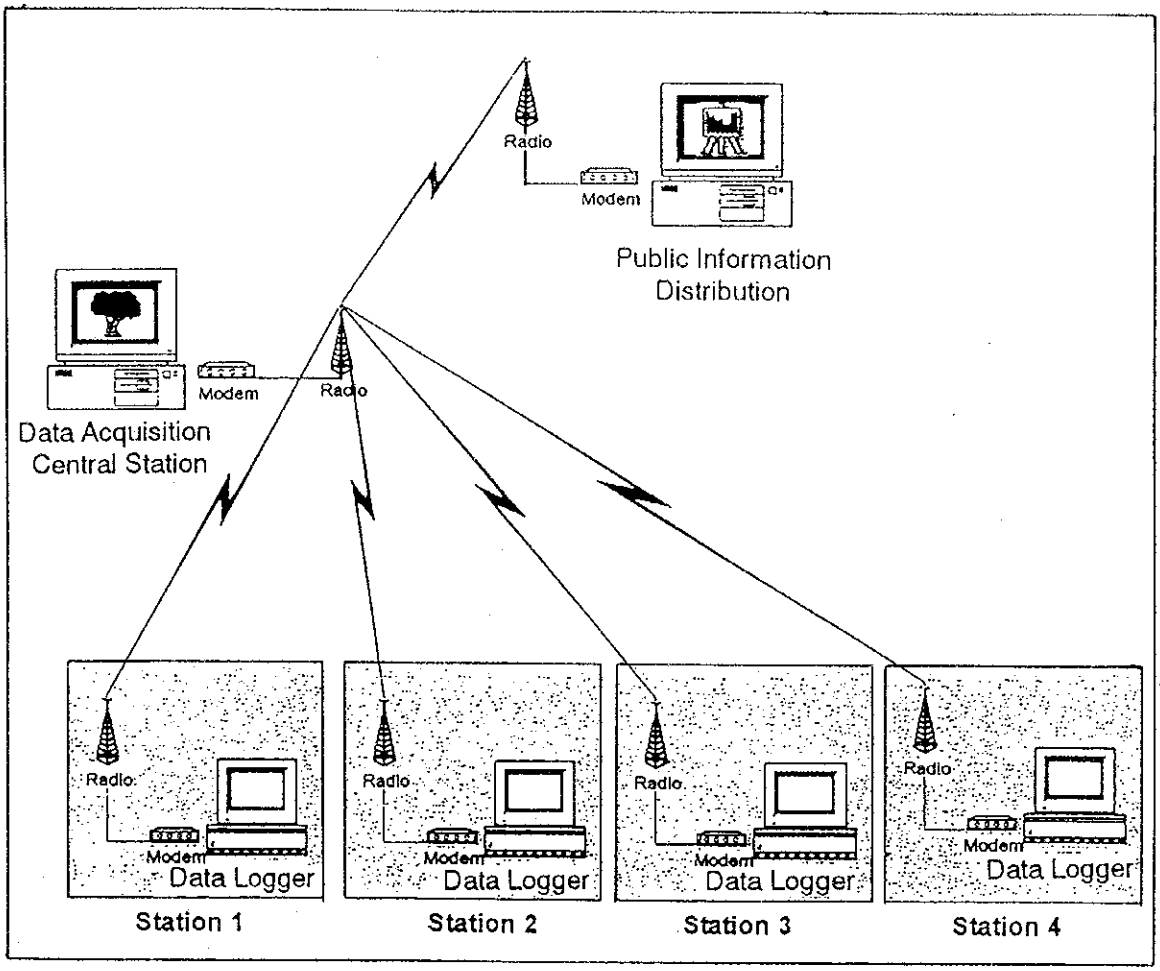


Figure 6.4 Overview of Public Information Distribution System

6.2.7 Planning for APMC

(1) Monitoring Equipment and Materials

Central station for monitoring will be stationed at the APMC. The APMC maintains and manages all the equipment and materials for monitoring and inspection system listed in Sections 6.2.2 (p.6-7), 6.2.3 (p.6-10), 6.2.4 (p.6-11) and 6.2.5 (p.6-12), respectively. The present central station at the MOE that provided in the course of the Study will be integrated with the APMC

(2) Hardware and Software for Data Acquisition and Processing

It is necessary to install hardware such as PC, server and printer and software in order that the APMC manages the monitoring data sent from the monitoring stations for air quality and stationary emission source and mobile monitoring, and the inspection data of automobile exhaust gas. All the data will be stored in the data bank system to be

installed in the APMC. The details of hardware and software for data acquisition and processing to be installed at the APMC are described in Section 6.2.6 (p.6-14).

6.2.8 Planning for Laboratory of IEZ

It is necessary to take into consideration the purpose of analysis as well as accuracy and detection limits, etc., in the improvement planning for analytical instruments of the IEZ. In addition, the number and performance of equipment and materials should also be decided depending on the number of samples to be treated and analyzed.

Black smoke is monitored for particulate matter but the measurement of Black Smoke is based on the relative method. It is therefore desirable to measure the weight concentration with high volume air sampler and it is recommended that about five units of high volume air sampler (portable type) be introduced for the monitoring of particulate matter in the model city.

Freon was not in problem in the past but tends to be analyzed as a hazardous substance as ozone layer depletion and grovel worming gas at present. It is important to keep in mind that such hazardous substance to be analyzed will increase in future, too. It is therefore necessary to make a plan for the improvement in analytical instruments of the IEZ taking into consideration the requirements and functions to be added in future. At the same time, however, it is also taken into consideration that the introduction of equipment and materials based on the particular purpose because the present equipment and materials can not satisfy all the requirements and functions in future. Upgrading the functions of the IEZ to the modern state-of-the-art ones in order to produce the highly precise data contributes in the progress for not only the environmental management but also the quality control, and ultimately is connected to the economic and technological development of Macedonia in the future. The function of the IEZ can be categorized into general or routine analysis, research and development, social education, etc..

Equipment and materials to be needed for the improvement of the IEZ at the first and second phase are listed in Table 6.7.

Table 6.7 (1) List of Equipment and Materials for Improvement of the IEZ

No.	Name of Equipment	Q'ty			
		Exist -ing	Phase 1st	Phase 2nd	Total
1	Air Compressor		1		1
2	Aspirator		1		1
3	Atomic Absorption Spectrometer With Graphite Furnace		1		1
4	Autoclave	1			1
5	Automatic Titrator		1		1
6	Balance (Electronic Analytical Balance)		1		1
7	Balance (Electronic Balance; 0.01g, 800g)		1		1
8	Balance (Electronic Balance; 0.1g, 5000g)		1		1
9	Balance (Top Loading Balance; 0.01g, 200g)			1	1
10	Blender (Mixer)		1		1
11	Bomb Calorimeter	1			1
12	Centrifuge (Cooling Centrifuge; 20,000 r.p.m, 500ml x 4pcs etc.)		1		1
13	Centrifuge (Desk Type Centrifuge; 5,000r.p.m., 15ml x 32pcs, etc.)			1	1
14	Centrifuge (High Speed Centrifuge; 15,000r.p.m., 10ml x 8pcs, etc.)			1	1
15	Constant Temperature Bath (Low Temperature Water Bath)		1		1
16	Constant Temperature Bath (Water Bath)			1	1
17	Constant Temperature Bath (Water Bath Shaker)			1	1
18	Data Bank System		1		1
19	Data Bank System (Network accessories)			1	1
20	Digital Density Meter		1		1
21	Digital Electronic Titration Burette	1			1
22	Dispensers (Dispensers Kit)	1			1
23	Dispensers (Micro Dispensers Kit)	1			1
24	Draft Chamber	1	1		2
25	Draft Chamber (With Gas Treatment Facility)		1		1
26	Drying Oven (Clean Oven)	1			1
27	Drying Oven (Forced Convection Constant Temperature Oven)			1	1
28	Drying Oven (Inert Gas Oven)		1		1
29	Drying Oven (Precision Constant Temperature Oven)		1		1
30	Filtration Devices		1		1
31	Flash Point Tester	1			1
32	Freezer, Ultra-low Temperature Freeze	1			1
33	Gas Chromatograph (FID , ECD) with Thermal Desorption System			1	1
34	Gas Chromatograph (FID, TCD, FPD)	1			1
35	Heating Apparatus (Heating Block)		1		1
36	Heating Apparatus (Hot Plate)	1			1
37	High Performance Liquid Chromatograph	1			1
38	High Temperature Furnace (Gas Replacement Vacuum Furnace)			1	1
39	High Temperature Furnace (High Temperature Electric Furnace)		1		1
40	High Temperature Furnace (Muffle Furnace)			1	1
41	High Temperature Furnace (Ultra-High Temperature Electric Furnace)		1		1
42	Homogenizer (Omni-Mixer Homogenizer)			1	1
43	Homogenizer (Ultrasonic Homogenizer)		1		1
44	Humidity Chamber (Constant Temperature Humidity Chamber)		1		1
45	Infrared Heater Type Water Content Meter			1	1
46	Low Temperature Plasma Asher			1	1
47	Melting Point Automatic Tester			1	1
48	Mercury Analyzer		1		1
49	Microscope with Camera System			1	1
50	Microwave Digestor	1			1
51	Mill (Laboratory Mill)			1	1
52	Mill (Universal Ball Mill)	5			5
53	Platinum Basin		1		1
54	Refrigerator		1		1

Table 6.7 (2) List of Equipment and Materials for Improvement of the IEZ

No.	Name of Equipment	Q'ty			
		Exist -ing	Phase 1st	Phase 2nd	Total
55	Rotary Evaporator with Bath		1		1
56	Sequential Tube Sampler (25samples) for thermal desorption system			1	1
57	Shaker (Level/Vertical Shake Type)		1		1
58	Shaker (Rotation/Shake Change, Large)		1		1
59	Sieve Shake+C16r		1		1
60	Soil Sampler		1		1
61	Spectrophotometer(FT-IR Spectrophotometer)		1		1
62	Spectrophotometer(Spectro fluoro photometer)			1	1
63	Spectrophotometer(UV-VIS Spectrophotometer (Double Beam))		1		1
64	Stirrer (Lab-Stirrer)			1	1
65	Stirrer (Magnetic Stirrer with Heater; Heat 6 pieces)			1	1
66	Stirrer (Magnetic Stirrer)	1	1		2
67	Vacuum Desiccator		1		1
68	Vacuum Oven		1		1
69	Vacuum Pump		1		1
70	Vivro Viscometer		1		1
71	Washer, Laboratory Glassware Washer		1		1
72	Washer, Ultrasonic Cleaner	1			1
73	Washer, Ultrasonic Pipette Cleaner		1		1

6.3 Organization and Institution Planning

(1) Establishment of Air Pollution Monitoring Center (APMC)

According to the "1996 Law on Environment and Nature Protection and Promotion," the MOE became an executing body of environmental administration including the environmental monitoring and policy-making for the prevention of air pollution. In order to monitor the environment effectively and to solve the various problems mentioned above under the newly established MOE, it is recommended that the APMC be established in Environmental Consulting Center of the MOE. Figure 6.5 shows an example of organization chart of the APMC and the following works are expected to be assigned. In addition, in case the nationwide monitoring network is established, the APMC will also become the center.

- AQM, data collection and its screening
- Continuous Emission Monitoring (CEM), data collection and its screening
- Judging whether the standards are cleared or not
- Data collection related to emission source and meteorology

- Management of monitoring data in data bank
- Maintenance and management of monitoring instruments

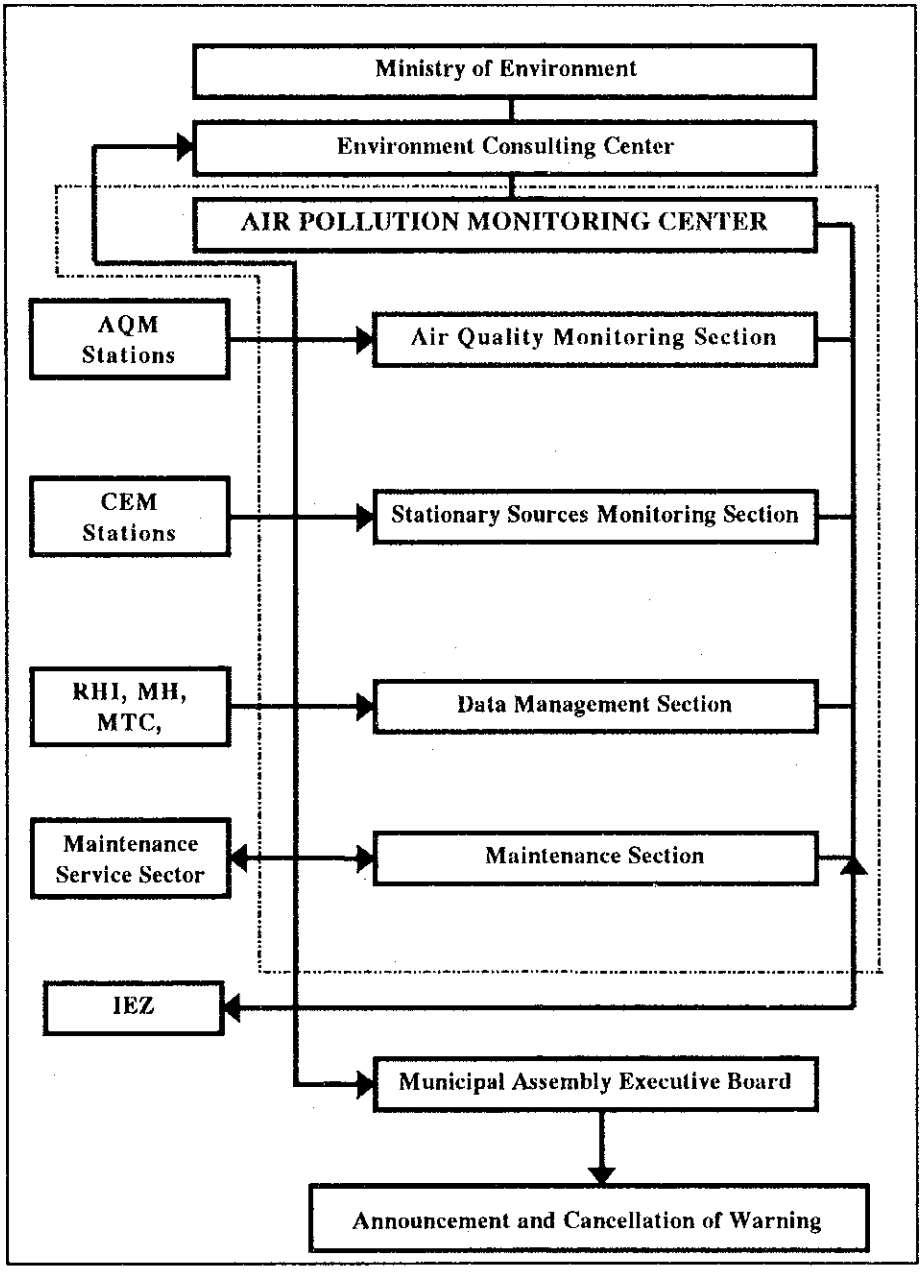


Figure 6.5 Organization Chart of Air Pollution Monitoring Center

1) Organization of APMC and Role of Each Section

The APMC comprises of the following four sections.

a) AQM Section

The works of this section include the followings:

- Continuous monitoring of data sent from AQM stations established in Skopje and other cities in Macedonia via communication line
- Acquisition of data after the validation of error data
- Judging whether the standards are cleared or not

b) CEM Section

The works of this section include the followings:

- Continuous monitoring of data sent from CEM station installed at the stationary emission source via communication line
- Acquisition of data after the validation of error data
- Judging whether the standards are cleared or not

c) Data Management Section

The works of this section include the followings:

- Integrated management of various data acquired to the APMC
- On- or off-line accumulation of data into data bank
- Handling of emission inventory of stationary emission source, data of mobile emission source, data of concentration and meteorological observation of the MH and the RHI, and data from the IEZ which is the environmental institute under the direct supervision of the MOE
- Export of data to the public information distribution system

d) Maintenance Section

It is recommended that the maintenance and management of instruments for AQM and CEM be outsourced to the local agent for the regular replacement of consumables and spare parts, and repairs of monitoring instruments at the time of trouble.

2) Other Works of APMC

Other works of the APMC include announcement of alarm when high concentration of air pollution appears in winter and conveys the information about suitable countermeasures to the organizations concerned. The establishment of AQM station for air pollution makes it possible to obtain one-hour monitoring in addition to the existing 24-hour monitoring data. The alarm is however announced based not on the short-term evaluated data but on the 24-hour monitoring data. Before the monitoring method for environmental standards is revised, it is necessary to take actions in an emergency case by referring to the evaluation criteria for short-term of WHO.

(2) Personnel Planning

For the effective operation of the APMC, the following administrative officers and engineers are required.

- Two administrative managers
- Six environmental engineers for monitoring, analysis, data management and maintenance
- Two electronics engineers for computation and communication

General office hours of the APMC follow the other administrative conditions. It is however necessary to arrange 24-hour shifting of personnel and provide against an emergency which it is expected that such a serious air pollution as stagnation occurs and that the alarm is announced depending on the meteorological conditions.

(3) Personnel Development Planning

Enough attention should be paid to the operation of the APMC because the newly established monitoring system differs from the existing one from the technical viewpoint. That is to say, hardware such as monitoring instruments and computer equipped with microchip and software to run the hardware are introduced into the monitoring system. It is difficult to cope with the existing techniques in O & M of monitoring instruments and extensive knowledge about the overall environment is required. It is therefore necessary for the administrative officers and engineers to receive the step-by-step training and re-education for the operation of the APMC.

1) Short-term Training

Short-term training includes the followings:

- Training held by manufacturer at site
- Lecture and training by newly employed researcher or technical adviser such as professor of university

2) Medium- and Long-term Training

Medium- and long-term training include the followings:

- Three to six months training at environmental monitoring institutes related to JICA or EU
- Training of engineer at environmental department to be established in university after arrangement with the organizations concerned
- Receiving of expert dispatch of JICA

6.4 Planning on Maintenance and Management

6.4.1 Installation Condition of Monitoring Instruments

At the time of installation of monitoring instruments it is necessary to pay attention to the following local conditions:

(1) Vibration

Monitoring instruments equip with vibration source such as pump which causes influence on the other monitoring instruments placed on the wooden floor. Vibration-proof measures to prevent the vibration to the other instruments shall be provided.

(2) Corrosive Gas and Dust

The corrosive gases and dust emission may cause troubles in the monitoring instruments. Thus the preventive measures from penetrating into the monitoring station and instruments shall be taken. The use of reagents producing corrosive gas shall be minimized.

(3) Temperature and Humidity

In order to secure the normal operation of monitoring instruments, it is an indispensable condition to keep the temperature and humidity in shelter constant because the sensitive electronic parts are used. The general operating temperature

range is 5 to 35℃ approximately. High humidity may condenses into water drops forming rust inside the monitoring instruments. On the other hand, low humidity may generate static electricity causing the malfunction.

(4) Fluctuation of Voltage and Frequency

There should be neither large electromagnetic induction facility nor generator of spark discharge nearby the monitoring instruments. Depending upon the local conditions the lightening protection shall be provided.

(5) Level

Horizontal level shall be secured to the floor at the time of installation of monitoring instruments.

(6) Easiness and Safety of Maintenance Works

Maintenance and repair works of monitoring instruments sometimes have to be made from the backside of monitoring instruments. Thus it is desirable to provide enough space between the wall of monitoring station and the backside of monitoring instruments for maintenance and repair works.

(7) Sampling Tube

Shorter air sampling tube reduces the entering of rain water and exhaust gas into the monitoring instruments.

6.4.2 Maintenance of Monitoring Station

(1) Difference in Temperature

Measurement errors may be caused inside of the monitoring instruments when the temperature at the time of installation is different from that of calibration period. Thus it is advisable to install the air conditioner in order to minimize the temperature difference between installation and calibration. The precaution shall also be taken to the application of air conditioner in summer because the moisture content in air sample condenses and the condensed water leads to measurement error as the results of lowering the station room temperature compared with the outside temperature. It is therefore necessary to pay full attention to the difference in the temperatures among

installation, calibration and operation.

(2) Maintenance of Air Sampling Tube

The fouling and stain inside the air sampling tube often affect the adsorption or disintegration of monitoring pollutants and thereby leads to reading errors. Thus it is necessary to replace or clean the air sampling tube periodically or more frequently per year depending upon the monitoring conditions. It is also important to inspect the leakage at the air sampler connection part.

6.4.3 Maintenance of Monitoring Instruments

For continuous monitoring of air pollutants, automatic air pollution monitoring instruments have to be effectively and reasonably operated with high reliability. Basic maintenance works for monitoring instruments to keep accuracy of value and reliability at high level are described below.

(1) Maintenance System

1) Engineer

It is necessary to station appropriate special engineers according to the number of monitoring station and the items of monitoring instruments in order to maintain and manage the monitoring station effectively. In general it is said that one engineer can maintain 3 to 5 monitoring stations including ten items approximately.

2) Education and Training

In order to operate various monitoring instruments for continuous monitoring with stable accuracy for long period, it is necessary to acquire enough knowledge for the various monitoring instruments and keep up with the latest technology and information.

3) Facility and Equipment

Maintenance works for monitoring instruments at the monitoring station include the check of sample flow, standard gases, replacement of filters and so on. Spare parts and consumables meeting the number of monitoring station and instruments items shall be stocked. The checkpoints of monitoring station are as follows:

- Status of data information processing
- Spare parts and consumables storage
- Chemicals including standard gases
- Instruments adjustment
- Data storage
- Vehicle
- Electricity and security

4) Management of Maintenance

It is important factors how to design and arrange the management system. For example, it is necessary to prepare, for easy application, various data files such as maintenance schedule, maintenance record, and data file for maintenance of monitoring instruments and monitoring stations.

5) Maintenance Schedule

Maintenance schedule for each monitoring instrument according to its maintenance procedures is required for systematic check of all the monitoring instruments without failure. For that purpose, it is necessary to prepare both annual and monthly schedule as maintenance schedule.

6) Maintenance Record

In order to keep the record of maintenance works, there is checking book for daily check in sheet style and report for regular check in score table style. It is important to design the way of maintenance record according to its purpose. For example, the following items can be recorded, when, where and who find what kind of trouble on which monitoring instruments, how it is repaired, when the repair is completed, and how to re-start it after repairs.

(2) Maintenance of Monitoring Instruments

In order to keep the accuracy and performance of each monitoring instrument and keep on acquiring the normal monitoring data for more than 20 hours a day, more than 600 hours a month, and more than 7,500 hours a year, it is necessary to inspect and check the monitoring instruments periodically as follows. The major items and schedule for maintenance works are summarized in Table 6.8.

Table 6.8 Major Items and Schedule for Maintenance Works

Check	Purpose	Frequency	Content
Daily check	Continuous normal operation of automatic monitoring instruments	Minimum once/week	1. Check of operation status of monitoring instruments 2. Replacement of consumables 3. Calibration 4. Cleaning
Periodical check (Close check) (Check of transmission accuracy)	Functions and prevention of trouble (keep within accuracy standards)	Minimum once/year	1. Inspection of flow path 2. Inspection of detector 3. Inspection of control and transmission systems 4. Inspection of amplifiers and recorders
Emergency check	Rapid and prompt check for trouble shooting when malfunction or breakdown	At the time of emergency	1. Identification of breakdown and its minor repairs 2. Identification of cause and repair by manufacturer
Function test	Prevention of trouble and to secure the continuous maintenance and data evaluation (required thorough comprehension of equipment characteristics)	When purchasing equipment and when necessary	1. Equipment function test (standard gas) 2. Equipment stability test (fluctuation of flow, zero, span drift, etc.) 3. Validation of monitoring data
Calibration with standard gas	Determination of the accuracy range	When necessary	1. Check with standard gas 2. Compile calibration curve

1) Spot Check

The status of data acquisition, storage and processing via telemetric system are subject to the fluctuation from moment to moment, it is therefore essential to religiously conduct spot checks and maintenance for the monitoring instruments, and to pay close attention so that no fault arises in the data.

2) Daily Check

Daily check is to confirm operating conditions of monitoring instruments. The works include patrolling of station once a day, or at least once a week, checking on whether or not there is any trouble in monitoring instruments, and to replace consumables and/or spare parts if any trouble is found. Since daily check is done visually, check items are to be standardized to eliminate personal difference. It is recommended to keep checking books for monitoring station and instruments, and to record the results immediately at the station.

3) Periodical Check

Periodical check is to secure the accuracy and performance of monitoring instruments.

The works include confirmation and calibration for measuring accuracy of instruments and replacement of degraded parts. The frequency of parts replacement and confirming of measurement accuracy depend upon the types of monitoring instruments.

4) Emergency Check

Emergency check is to immediately investigate causes of troubles, which are found through the daily confirmation or daily check, and to take necessary steps for the restoration of operational condition. The works require profound knowledge of monitoring instruments and broad experience of trouble shooting.

(3) Other Maintenance

1) Performance Test

It is desirable to execute the regular performance test at the time of purchasing of monitoring instruments, repairs, regular inspection and overhaul considering requirements of continuous data acquisition, maintenance and prevention plan and its economics.

2) Overhaul

In case it is found difficult to maintain accuracy through regular check, overhaul is required. Overhaul is executed at the factory of manufacturer. Monitoring instruments are disassembled and the performance of each part is tested. If correct function and accuracy of each part are confirmed for a certain period or malfunctioned parts are repaired or replaced, the monitoring instruments are re-assembled. Since the overhaul is provided at the place with well-equipped facility and with enough time, total guarantee can be secured.

3) Necessity of Spare Instruments

Spare instruments are useful in case trouble in monitoring instruments and/or abnormal value is found through the regular check or overhaul. It is desirable to secure the spare instruments for each monitoring instrument to replace in an emergency case.

6.4.4 Maintenance Management Software for Monitoring Instruments

Maintenance management software for monitoring instruments is a software which enhances the diagnostic function. When the central station receives the trouble message, trouble shooting will be displayed on the screen. Such maintenance management software is very convenient for getting a simple understanding of trouble shooting. It is therefore recommended that the software be introduced to the expansion of monitoring system in model city and for nationwide system.
The major functions are as follows:

- Automatic printing of right procedures of trouble shooting against the error message sent from the monitoring station
- Automatic printing of instruction for the regular maintenance schedule and its item
- Management of spare parts
- Scheduling of monthly maintenance works
- Reporting of monthly maintenance works
- Reporting of uncompleted monthly maintenance works

An example of the menu for maintenance management software is shown in Figure 6.6.

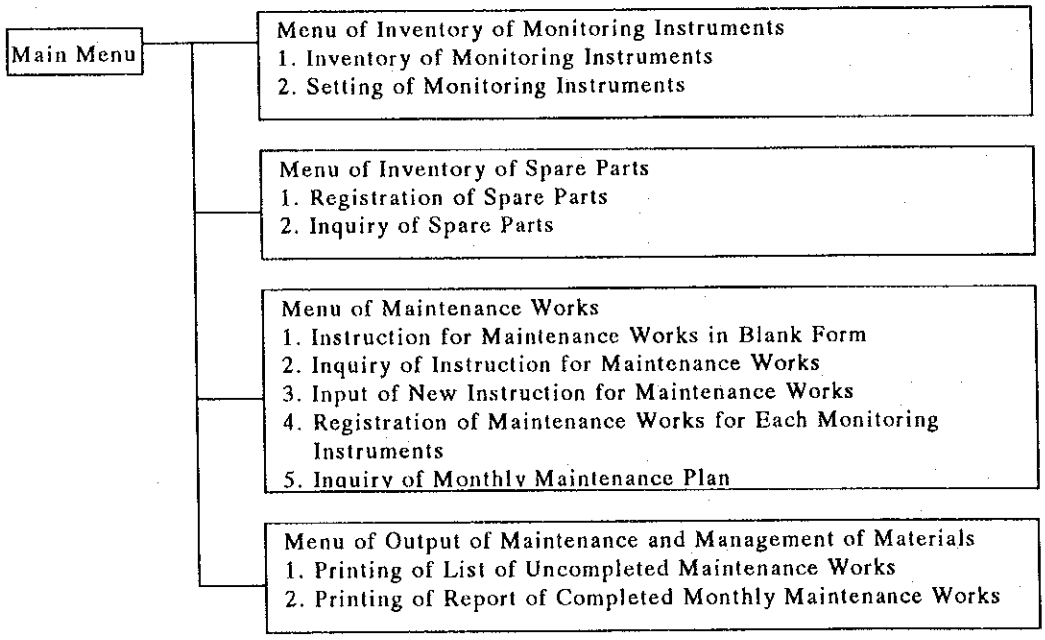


Figure 6.6 Overview of Menu of Maintenance Management Software

6.4.5 Maintenance and Management Planning on Equipment and Materials Procured for the Study

The four AQM stations and a mobile monitoring car in the model city procured and installed for the Study were provided for the Government of Macedonia based on the request after the completion of the Site Work IV in March, 1999. The maintenance and management for the monitoring equipment and materials should be carried out under the responsibility of the MOE. The processing and management of data sent continuously from AQM stations are one of the important jobs. Periodical maintenance makes it possible to use the monitoring equipment and materials up to following seven to ten years approximately.

(1) Personnel

In order to monitor the instantly varying ambient air quality continuously and validate the acquired data at the central station, it is recommended that an administrative officer and an environmental engineer should be posted at the central station. The environmental engineer judges whether the data acquired have abnormality or not and hands over statistically processed data to the administrative officer.
The administrative officer judges whether the processed data clear the environmental standards or not and takes necessary actions if required.

The concentration of SO_2 and SPM in winter and that of O_3 in summer exceeds the environmental standards in the model city. It is therefore necessary to post the full-time personnel for the continuous monitoring of data. It is also necessary for the personnel to have full knowledge of environmental administration, validation of data and monitoring instruments.

Mobile monitoring car is under the management of IEZ. Seven personnel comprising of two environmental engineers, four assistants and a driver are necessary for the emission monitoring and management because additional works at the site such as the preparation of monitoring instruments loaded on the vehicle, connection of sampling probe to the flue duct or stack, etc. are needed.

(2) Maintenance and Management

It is desirable that the specialized engineers of the MOE carry out basically all the maintenance and management works including check, inspection and calibration for AQM stations and monitoring instruments. It is necessary to keep up with the rapid progress in the monitoring instruments, as well as the computer technology of the

improved monitoring systems in the developed countries.

Monitoring instruments at AQM stations in the model city are completely different in the structure and principle from the existing monitoring equipment such as British sampler in Macedonia. The present monitoring instruments apply the state-of-the-art electronics and physical technology. Therefore it takes considerable time to acquire the O & M techniques even though the engineer receives training at the manufacturer of monitoring instruments.

Through the daily patrolling and inspection of AQM stations, simple maintenance works were provided by the engineer including the replacement of filter paper, calibration, status check of monitoring instruments, etc.. It can be said that the maintenance techniques are now at the initial level.

There are two options to maintain and manage the present AQM stations. The merit and demerit of each option are as follows.

1) Maintenance and Management by the MOE

It is possible to provide a basic maintenance of the monitoring instruments according to the given specification; monthly replacement of the filter papers of the analyzers for SO_2, CO, NOx and O_3, replacement of the filter papers of the TEOM on a 2-4 weeks basis depending on the air quality; quarterly replacement of the by-pass filters of the TEOM; replacement of the active coal and the purifier in each analyzer; complete calibration of all analyzers through the solution system once a month. Such a dynamic maintenance requires spare parts for at least one-month continuous operation of the system, which are to be provided by the MOE.

2) Outsourcing to Local Agent

In case all the maintenance and management works of AQM stations are outsourced to the local agent, it is possible firstly to secure the operation of monitoring instruments and the acquisition of monitoring data without the specially high-level techniques by way of completely outsourcing the responsibilities for the maintenance and management of stations to the local agent, and secondly to save the time and manpower for patrolling, trouble shooting, etc..

In order to understand a series of monitoring activities from the operation of monitoring instruments to the validation and evaluation of monitoring data, it is desirable that the MOE itself maintain and manage the monitoring stations. The

manpower of the MOE is sufficient for regular maintenance, but for more complex defects such as regular overhauls, it is necessary to collaborate with the local agent depending on the extent of maintenance and trouble in order to operate during long time and to acquire the maintenance techniques little-by-little through the daily maintenance works and co-works with local agent. Once enough knowledge and experiences for a series of monitoring activities including the maintenance of monitoring instruments are acquired, it is possible to make a decision whether the MOE itself maintains and manages the stations or outsource to the local agent, taking into consideration the other factors such as manpower, budget, etc.. In Japanese case, both two options mentioned above can be observed depending on the conditions of municipalities.

An engineer was dispatched only for the purpose of the Study, from the RHI to the MOE for maintenance and management of AQM stations and returned to the RHI in March 1999. It is however desirable that the MOE maintain and manage the present AQM system obtaining the technical cooperation from the engineer from the RHI consecutively.

6.5 Implementation Planning

Implementation schedule for the air pollution monitoring system in the model city is divided into three stages as mentioned below:

(1) Present Stage of Urgently Required Monitoring

It is possible to monitor the followings with the present AQM and mobile monitoring system introduced in the course of the Study:

- Four stations of AQM
- One set of stationary emission source monitoring with mobile monitoring car
- Dust monitoring in ambient air and its component analysis

(2) First Stage of Monitoring Plan within Five Years

- Setting up of additional two AQM stations
- Installation of three CEM stations
- Introduction of a mobile monitoring system
- Introduction of one set of auto-exhaust gas inspection system
- Establishment of the APMC including data bank system

- Improvement in analytical instruments of the IEZ (first phase)

AQM station and mobile monitoring system in the model city will comprise of six stations and two systems in total, respectively. Most of the establishment of monitoring system in the model city will therefore be completed in the first stage of implementation plan.

(3) Second Stage of Monitoring Plan within Ten Years

- Improvement in analytical instruments of the IEZ (second phase)

Most of the establishment of monitoring system in the model city will therefore be completed in the first stage of monitoring plan.

Table 6.9 shows the implementation schedule on the each stage.

Table 6.9 Implementation Schedule

Stages	Contents
Present stage (urgently required monitoring) The equipment was introduced in the course of the Study	- Four stations of AQM - One set of emission monitoring with mobile monitoring car - Dust monitoring in ambient air and its component analysis
First stage (within five years)	- Setting up of additional two AQM stations - Installation of three sets of CEM system to three large-scale stationary emission sources - One set of emission monitoring with mobile monitoring car - Introduction of a set of auto-exhaust gas inspection system - Establishment of the APMC including data bank system - Improvement in analytical instruments of the IEZ (first phase)
Second stage (within ten yeas)	- Improvement in analytical instruments of the IEZ (second phase)

6.6 Estimation for Project Expenses

6.6.1 Cost Estimation for Equipment and Materials

(1) Cost Estimation for AQM System

In addition to the present four AQM stations, it is recommended that two more AQM stations be newly set up in the model city. Major difference is that net radiation meter, maintenance car and upgraded public information system are added to the present monitoring system.
The estimated cost for AQM system is as follows and the details are shown in Table 6.10.

- Equipment and materials:	US$	428,200
- Consumables:	US$	6,780
- Spare parts:	US$	12,710
Total	US$	447,690

(2) Cost Estimation for CEM System

It is recommended that three sets of CEM equipment and materials be installed to three stacks of factories in the model city. This CEM system comprises of emission monitoring instruments, data logger and telemetric transmission system. The estimated cost for CEM system is as follows and the details are shown in Table 6.11.

- Equipment and materials:	US$	312,300
- Consumables:	US$	16,800
- Spare parts:	US$	6,400
Total	US$	335,500

(3) Cost Estimation for Mobile Monitoring System

The estimated cost for the introduction of another mobile monitoring car to monitor the stationary emission source and ambient air quality as well is as follows and the details are shown in Table 6.12.

- Equipment and materials:	US$	255,100
- Consumables:	US$	22,430
- Spare parts:	US$	1,200
Total	US$	278,730

(4) Cost Estimation for Auto-exhaust Gas Inspection System

The estimated cost for the recommended one set of auto-exhaust gas inspection system on the street is as follows and the details are shown in Table 6.13.

- Equipment and materials:	US$	78,500
- Consumables:	US$	5,240
- Spare parts:	US$	3,900
Total	US$	87,640

(5) Cost Estimation for APMC

Besides the present telemetric system, it is recommended that additional computer hardware and software be installed in APMC to be established. The estimated cost is as follows:

- Equipment and materials:	US$	148,000
- Consumables:	US$	2,500
Total	US$	150,500

(6) Cost Estimation for Improvement in Analytical Instruments of the IEZ

It is recommended that the improvement in analytical instruments of the IEZ be introduced by two steps. The estimated cost is as follows and the details are shown in Table 6.14.

- First phase:	US$	536,940
- Second phase:	US$	253,660
Total	US$	790,600

Table 6.10 Price List of Each Equipment and Materials for AQM System

Unit: US$

No.	Name of Equipment	Q'ty	Unit Price	Total Price
1	Fluorescent SO_2 Analyzer	2	10,400	20,800
2	Chemiluminescence NOx Analyzer	2	10,800	21,600
3	NDIR CO Analyzer	2	10,000	20,000
4	UV O_3 Analyzer	2	7,600	15,200
5	Suspended Particulate Matter Analyzer	2	18,400	36,800
6	Calibrator	2	18,900	37,800
7	Zero Air Generator	2	4,600	9,200
8	Standard Gas (NO, CO) 10 ℓ	4	3,100	12,400
9	Regulator (NO, CO)	4	2,600	10,400
10	Recorder (12 dot)	2	2,600	5,200
11	Sample Manifold with Heater	2	2,800	5,600
12	Wind Direction & Speed Meter	2	2,300	4,600
13	Thermometer / Hygrometer	2	2,000	4,000
14	Solar Radiation Meter	2	2,700	5,400
15	Net Radiation Meter	2	8,800	17,600
16	Meteorological Data Translator	2	2,400	4,800
17	Data Logger with Telemeter System	2	20,000	40,000
18	Automatic Voltage Stabilizer 8 kVA, single phase	2	5,000	10,000
19	Automatic Delayed Restoration Device from Power Failure	2	3,200	6,400
20	Rack for Analyzer	2	1,900	3,800
21	High Volume Sampler (outdoor)	2	8,800	17,600
22	Shelter with Air Conditioner	2	24,000	48,000
23	UPS (30 minutes Back Up) 5 kVA	2	7,200	14,400
24	Public Information System	1	10,400	10,400
25	Maintenance Car	1	14,400	14,400
26	Installation and Start Up	2	4,800	9,600
27	Training	2	3,500	7,000
28	Transportation and Insurance	2	4,000	8,000
29	Foundation Work for Shelter	2	1,600	3,200
30	Fence Works for Monitoring Stations	2	2,000	4,000
			Total	428,200

No.	Consumables for One Year Operation	Q'ty	Unit Price	Total Price
1	Fluorescent SO_2 Analyzer	2	280	560
2	Chemiluminescence NOx Analyzer	2	360	720
3	NDIR CO Analyzer	2	280	560
4	UV O_3 Analyzer	2	270	540
5	Suspended Particulate Matter Analyzer	2	240	480
6	Calibrator SO_2 PMT	2	460	920
7	Zero Air Generator	2	300	600
8	Standard Gas (NO, CO) 10 ℓ	2	800	1,600
9	Recorder	2	240	480
10	Filter for High Volume Sampler	2	160	320
			Total	6,780

No.	Spare Parts	Q'ty	Unit Price	Total Price
1	Fluorescent SO_2 Analyzer	1	1,900	1,900
2	Chemiluminescence NOx Analyzer	1	2,000	2,000
3	NDIR CO Analyzer	1	500	500
4	UV O_3 Analyzer	1	330	330
5	Suspended Particulate Matter Analyzer	1	1,600	1,600
6	Calibrator SO_2 PMT	1	1,680	1,680
7	Zero Air Generator	1	600	600
8	High Volume Sampler	1	4,100	4,100
			Total	12,710

Table 6.11 Price List of Each Equipment and Materials for CEM System

Unit: US$

No.	Name of Equipment	Q'ty	Unit Price	Total Price
1	Multi-Gas Analyzing System (SO_2, NOx, CO, O_2) Outdoor	3	48,000	144,000
2	Opacity Meter	3	16,000	48,000
3	Data Logger with Telemeter System	3	20,000	60,000
4	Standard Gas (SO_2, NO, CO, N_2, O_2) 10 ℓ	15	800	12,000
5	Regulator (SO_2, NO, CO, N2, O_2)	15	1,300	19,500
6	Installation and Start Up	3	3,600	10,800
7	Training	3	2,400	7,200
8	Transportation and Insurance	3	3,600	10,800
			Total	312,300

No.	Consumables for One Year Operation	Q'ty	Unit Price	Total Price
1	Analyzer (SO_2, NO, CO, O_2)	3	1,600	4,800
2	Standard Gas (SO_2, NO, CO, O_2, N_2) 10 ℓ	15	800	12,000
			Total	16,800

No.	Spare Parts	Q'ty	Unit Price	Total Price
1	Analyzer	1	6,400	6,400
			Total	6,400

Table 6.12 Price List of Each Equipment and Materials for Mobile Monitoring System

Unit: US$

No.	Name of Equipment	Q'ty	Unit Price	Total Price
1	Fluorescent SO_2 Analyzer	1	10,400	10,400
2	Chemiluminescence NOx Analyzer	1	10,800	10,800
3	NDIR CO Analyzer	1	10,000	10,000
4	UV O_3 Analyzer	1	7,600	7,600
5	Suspended Particulate Matter Analyzer	1	18,400	18,400
6	Dilution Unit with O_2 Sensor & Zero Air Generator	1	20,800	20,800
7	Automatic Isokinetic Dust Sampler	1	38,400	38,400
8	Mass Flow Calibrator	1	18,900	18,900
9	Zero Air Generator	1	4,600	4,600
10	Standard Gas (SO_2, NO (H&L), CO(H &L), O_2, N_2) 10 ℓ	7	800	5,600
11	Regulator (SO_2, NO (H&L), CO(H &L), O_2, N_2)	7	1,300	9,100
12	Recorder (12 dot)	1	2,600	2,600
13	Data Logger with UPS	1	3,000	3,000
14	Impactor for Flue Gas	1	12,000	12,000
15	Automatic Voltage Stabilizer 10 kVA, single phase	1	2,800	2,800
16	Monitoring Car (Truck chassis)	1	16,000	16,000
17	Monitoring Car (Shelter on truck)	1	24,000	24,000
18	Rack for Analyzer	1	1,000	1,000
19	Wind Direction & Speed Meter	1	2,300	2,300
20	Thermometer / Hygrometer	1	2,000	2,000
21	Meteorological Data Processor	1	2,400	2,400
22	Sampler ; High Volume Sampler (outdoor)	1	8,800	8,800
23	Sample Manifold	1	2,800	2,800
24	Tool Set	1	800	800
25	Telescopic Pole for Meteorological Meters	1	1,200	1,200
26	Installation and Start Up	1	3,600	3,600
27	Training	1	8,000	8,000
28	Transportation and Insurance	1	7,200	7,200
			Total	255,100

No.	Consumables for One Year Operation	Q'ty	Unit Price	Total Price
1	Fluorescent SO_2 Analyzer	1	300	300
2	Chemiluminescence NOx Analyzer	1	360	360
3	NDIR CO Analyzer	1	280	280
4	UV O_3 Analyzer	1	270	270
5	Suspended Particulate Matter Analyzer	1	240	240
6	Calibrator SO_2 PMT	1	460	460
7	Zero Air Generator	1	300	300
8	Standard Gas (SO_2, NO(H&L), CO(H&L),O_2, N_2) 10 ℓ	7	2,800	19,600
9	Recorder	1	240	240
10	Filter for Impactor	1	220	220
11	Filter for High Volume Sampler	1	160	160
			Total	22,430

No.	Spare Parts	Q'ty	Unit Price	Total Price
1	Dilution Unit with O_2 Sensor & Zero Air Generator	1	1,200	1,200
			Total	1,200

Table 6.13 Price List of Each Equipment and Materials for Auto-exhaust Gas Inspection System

Unit: US$

No.	Name of Equipment	Q'ty	Unit Price	Total Price
1	Exhaust Gas Analyzer (CO, CO_2, HC, O_2)	1	19,200	19,200
2	Diesel Smoke Meter (Filter paper reflection type)	1	20,400	20,400
3	Air Compressor for Diesel Smoke Meter	1	1,000	1,000
4	Standard Gas for Exhaust Gas Analyzer	3	800	2,400
5	Regulator	3	1,300	3,900
6	Mobil Car with Air Conditioner and Power Generator	1	21,600	21,600
7	Tool Set	1	800	800
8	Training	1	3,200	3,200
9	Transportation and Insurance	1	2,800	2,800
10	Engineering	1	3,200	3,200
			Total	78,500

No.	Consumables for One Year Operation	Q'ty	Unit Price	Total Price
1	Exhaust Gas Analyzer	1	560	560
2	Filter Paper	60	40	2,400
3	Standard Gases (CO, NO, CO_2)	3	760	2,280
			Total	5,240

No.	Spare Parts	Q'ty	Unit Price	Total Price
1	Exhaust Gas Analyzer	1	1,900	1,900
2	Diesel Smoke Tester	1	2,000	2,000
			Total	3,900

Table 6.14 (1) Price List of Each Analytical Instruments for Improvement of the IEZ

Unit: US$

No.	Name of Equipment	Q'ty				Price		
		Exist -ing	Phase 1st	Phase 2nd	Total	Unit	Phase 1st	Phase 2nd
1	Air Compressor		1		1	2,600	2,600	
2	Aspirator		1		1	720	720	
3	Atomic Absorption Spectrometer With Graphite Furnace		1		1	104,000	104,000	
4	Autoclave	1			1	4,900		
5	Automatic Titrator		1		1	11,200	11,200	
6	Balance (Electronic Analytical Balance)		1		1	2,000	2,000	
7	Balance (Electronic Balance; 0.01g, 800g)		1		1	1,500	1,500	
8	Balance (Electronic Balance; 0.1g, 5000g)		1		1	1,400	1,400	
9	Balance (Top Loading Balance; 0.01g, 200g)			1	1	560		560
10	Blender (Mixer)		1		1	1,000	1,000	
11	Bomb Calorimeter	1			1	7,400		
12	Centrifuge (Cooling Centrifuge; 20,000 r.p.m, 500ml x 4pcs etc.)		1		1	21,600	21,600	
13	Centrifuge (Desk Type Centrifuge; 5,000r.p.m., 15ml x 32pcs, etc.)			1	1	3,200		3,200
14	Centrifuge (High Speed Centrifuge; 15,000r.p.m., 10ml x 8pcs, etc.)			1	1	8,000		8,000
15	Constant Temperature Bath (Low Temperature Water Bath)		1		1	3,200	3,200	
16	Constant Temperature Bath (Water Bath)			1	1	1,600		1,600
17	Constant Temperature Bath (Water Bath Shaker)			1	1	2,400		2,400
18	Data Bank System		1		1	132,000	132,000	
19	Data Bank System (Network accessories)			1	1	12,800		12,800
20	Digital Density Meter		1		1	1,400	1,400	
21	Digital Electronic Titration Burette	1			1	8,000		
22	Dispensers (Dispensers Kit)	1			1	1,200		
23	Dispensers (Micro Dispensers Kit)	1			1	1,600		
24	Draft Chamber	1	1		2	12,000	12,000	
25	Draft Chamber (With Gas Treatment Facility)		1		1	20,000	20,000	
26	Drying Oven (Clean Oven)	1			1	11,400		
27	Drying Oven (Forced Convection Constant Temperature Oven)			1	1	3,600		3,600
28	Drying Oven (Inert Gas Oven)		1		1	5,200	5,200	
29	Drying Oven (Precision Constant Temperature Oven)		1		1	4,400	4,400	
30	Filtration Devices		1		1	2,000	2,000	
31	Flash Point Tester	1			1	14,400		
32	Freezer, Ultra-low Temperature Freeze	1			1	9,600		
33	Gas Chromatograph (FID , ECD) with Thermal Desorption System			1	1	92,800		92,800
34	Gas Chromatograph (FID, TCD, FPD)	1			1	28,000		
35	Heating Apparatus (Heating Block)		1		1	1,100	1,100	
36	Heating Apparatus (Hot Plate)	1			1	720		
37	High Performance Liquid Chromatograph	1			1	88,000		
38	High Temperature Furnace (Gas Replacement Vacuum Furnace)			1	1	16,800		16,800
39	High Temperature Furnace (High Temperature Electric Furnace)		1		1	17,600	17,600	
40	High Temperature Furnace (Muffle Furnace)			1	1	2,600		2,600
41	High Temperature Furnace (Ultra-High Temperature Electric Furnace)		1		1	26,400	26,400	
42	Homogenizer (Omni-Mixer Homogenizer)			1	1	9,600		9,600
43	Homogenizer (Ultrasonic Homogenizer)		1		1	5,400	5,400	
44	Humidity Chamber (Constant Temperature Humidity Chamber)		1		1	8,000	8,000	
45	Infrared Heater Type Water Content Meter			1	1	2,600		2,600
46	Low Temperature Plasma Asher			1	1	32,000		32,000
47	Melting Point Automatic Tester			1	1	8,800		8,800
48	Mercury Analyzer		1		1	14,200	14,200	
49	Microscope with Camera System			1	1	22,400		22,400
50	Microwave Digestor	1			1	36,000		
51	Mill (Laboratory Mill)			1	1	6,500		6,500
52	Mill (Universal Ball Mill)	5			5	100		
53	Platinum Basin		1		1	640	640	
54	Refrigerator		1		1	2,200	2,200	

Table 6.14 (2) Price List of Each Analytical Instruments for Improvement of the IEZ

Unit: US$

No.	Name of Equipment	Qty				Price		
		Exist-ing	Phase		Total	Unit	Phase	
			1st	2nd			1st	2nd
55	Rotary Evaporator with Bath		1		1	6,000	6,000	
56	Sequential Tube Sampler (25samples) for thermal desorption system			1	1	8,400		8,400
57	Shaker (Level/Vertical Shake Type)		1		1	1,400	1,400	
58	Shaker (Rotation/Shake Change, Large)		1		1	3,200	3,200	
59	Sieve Shaker		1		1	3,500	3,500	
60	Soil Sampler		1		1	9,200	9,200	
61	Spectrophotometer(FT-IR Spectrophotometer)		1		1	44,000	44,000	
62	Spectrophotometer(Spectro fluoro photometer)			1	1	16,800		16,800
63	Spectrophotometer(UV-VIS Spectrophotometer (Double Beam))		1		1	24,000	24,000	
64	Stirrer (Lab-Stirrer)			1	1	600		600
65	Stirrer (Magnetic Stirrer with Heater; Heat 6 pieces)			1	1	1,600		1,600
66	Stirrer (Magnetic Stirrer)	1	1		2	320	320	
67	Vacuum Desiccator		1		1	760	760	
68	Vacuum Oven		1		1	6,800	6,800	
69	Vacuum Pump		1		1	1,000	1,000	
70	Vivro Viscometer		1		1	8,000	8,000	
71	Washer, Laboratory Glassware Washer		1		1	24,000	24,000	
72	Washer, Ultrasonic Cleaner	1			1	1,200		
73	Washer, Ultrasonic Pipette Cleaner		1		1	3,000	3,000	
						Total	536,940	253,660
						Ground Total		790,600

(7) Total Cost Estimation

Total estimated cost for the establishment of air pollution monitoring system in the model city during both first and second stage would be US$ 2,090,660 including equipment and materials, annual consumables and spare parts. Table 6.15 shows the summary of cost estimation for air pollution monitoring system in the model city.

Table 6.15 Summary of Cost Estimation for Air Pollution Monitoring System in Model City

Unit : US$

Stage	Item	Cost Estimation			
		Equipment & Materials	Consumables	Spare Parts	Total
1st	AQM	428,200	6,780	12,710	447,690
1st	CEM	312,300	16,800	6,400	335,500
1st	Mobile monitoring	255,100	22,430	1,200	278,730
1st	Auto-exhaust gas inspection	78,500	5,240	3,900	87,640
1st	Software for data acquisition and processing for APMC	148,000	2,500	-	150,500
1st	Improvement in analytical instruments for IEZ (1st phase)	536,940	-	-	536,940
2nd	Improvement in analytical instruments for IEZ (2nd phase)	253,660	-	-	253,660
1st Stage Total		1,759,040	53,750	24,210	1,837,000
2nd Stage Total		253,660	-	-	253,660
Total		2,012,700	53,750	24,210	2,090,660

(8) Estimation for Maintenance Service Cost in the Model City

The estimated cost for the maintenance of air pollution monitoring system in the model city through the outsourcing to the local agent is as follows:

- Consumable:	US$	53,750
- Spare parts:	US$	24,210
- Fee of service engineer:	US$	16,000
- Transportation:	US$	16,000
Total	US$	109,960

6.6.2 Cost Estimation for Maintenance and Management of Present System

Annual cost for the maintenance and management of present monitoring system comprises of consumables, spare parts and service engineering fee. The annual cost estimation for the consumables and spare parts for the maintenance and management of four AQM stations and a mobile monitoring car is US$ 26,000 approximately. The cost for outsourcing to the local agent is US$ 32,000 approximately.

- Consumables:	US$	16,900
- Spare parts:	US$	9,100
- Fee of service engineer:	US$	16,000
- Transportation:	US$	16,000
Total	US$	58,000

6.6.3 Cost Estimation on Each Implementation Schedule

Table 6.16 shows cost estimation on each implementation schedule for establishment of monitoring system.

Table 6.16 Cost Estimation on Each Implementation Schedule

Unit : US$

Item \ Stage & Year	First Stage				
	1	2	3	4	5
Initial investment cost					
AQM system	428,200	-	-	-	-
CEM system	312,300	-	-	-	-
Mobile monitoring	255,100	-	-	-	-
Auto-exhaust gas inspection	78,500	-	-	-	-
Data acquisition and processing for APMC	148,000	-	-	-	-
Subtotal	1,222,100				
Annual O & M Cost					
Spare parts & consumables	77,960	77,960	77,960	77,960	77,960
Fee of service engineer & transportation (outsourcing case)	32,000	32,000	32,000	32,000	32,000
Subtotal	109,960	109,960	109,960	109,960	109,960
Other investment cost					
Improvement in analytical instrument for IEZ	536,940	-	-	-	-
Total	1,869,000	109,960	109,960	109,960	109,960

Item \ Stage & Year	Second Stage				
	6	7	8	9	10
Initial investment cost					
AQM system	-	-	300,600	300,600	300,600
CEM system	-	-	-	-	-
Mobile monitoring	-	-	-	-	227,000
Auto-exhaust gas inspection	-	-	-	65,000	-
Data acquisition and processing for APMC	-	-	150,000	-	-
Subtotal			450,600	365,600	527,600
Annual O & M Cost					
Spare parts & consumables	77,960	77,960	77,960	77,960	77,960
Fee of service engineer & transportation (outsourcing case)	32,000	32,000	32,000	32,000	32,000
Subtotal	109,960	109,960	109,960	109,960	109,960
Other investment cost					
Improvement in analytical instrument for IEZ	253,660	-	-	-	-
Total	363,620	109,960	560,560	475,560	637,560

6.7 Procurement Procedure

In order to establish the air pollution monitoring system, the proceeds of any loan of international financial institutions such as the International Bank for Reconstruction and Development (IBRD), the Overseas Economic Cooperation Fund of Japan (OECF) and so on may be applicable to the procurement of monitoring equipment and materials. The general procedures are summarized in Figure 6.7. The details are described in the guidelines being published by each financial institution.

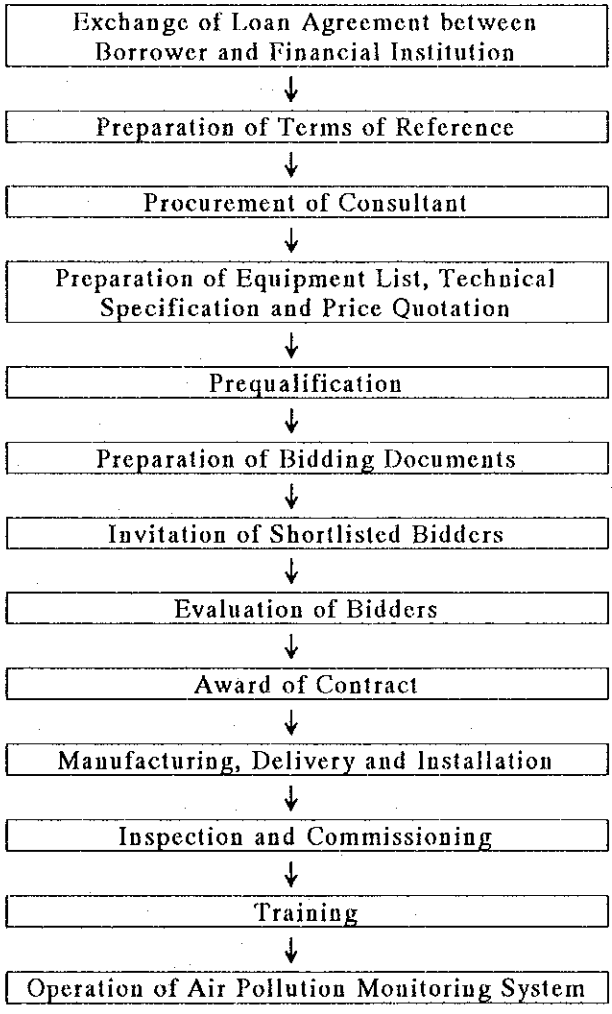


Figure 6.7 General Procurement Procedures under International Financial Institution

(1) Considerations for Procurement of Equipment and Materials

1) Bidding for Procurement

The procured equipment and materials may not be fully utilized if the manufacturer fails to provide the appropriate after-sales service. To ensure effective utilization over a long period, it is necessary before procurement that measures to prevent the manufacturer from simply selling of spare parts and materials and failing to provide after-sales service be incorporated in the specification. In this context, it is desirable to select a reliable bidder and a technically acceptable method without placing too much emphasis on the price only.

Prospective bidders must initially be pre-qualified to determine whether they are suitably qualified and then they will be requested to submit a proposal for supply of the equipment and materials. The content of the proposals must be reviewed beforehand and a few bidders will be selected. Subsequently, the bidding documents are distributed to the shortlisted bidders, requesting them to submit the technical and /or financial proposal(s) and bid bond. But two-envelope type bidding is desirable.

2) Preparation of Technical Specification

Preparation of a clearly understandable specification is the sole means to prevent trouble with the manufacturer during various procurement processes.

A vague specification may lead to such troubles as difference in the standard or the delivery of a different product due to a difference in the interpretation of the manufacturer.

The specification must be prepared by specifically describing the item, quantity and specification details. The delivery conditions must also be clearly defined upon presentation of the estimate by presenting the specification details to the manufacturer. Even when the specification has been prepared with careful consideration as above described, there are always inquiries from the participants during and after the bid orientation meeting. The executing agency must provide the technical reply to these questions. This requires that the above mentioned agency must have in-depth knowledge of the equipment and materials resulting from a careful study. It is therefore a general practice to have assistance from the consultant, concerning the procurement of the equipment and materials, including preparation of the specification. An example of the specification reviewed during development of the air pollution monitoring equipment and materials plan is introduced below while limiting the description to the principal equipment and materials (See Table 6.17). SO_2, NOx, CO, O_3 and SPM meters, ultrasonic wind-vane anemometer and container housing are dealt with here.

Table 6.17 (1) Example of the Specification (SO_2 Analyzer)

No.	Item	Specification
1. Equipment for Monitoring		
1-1	Ambient Air	
1-1-1	SO2 Analyzer	APPLICATION
		Continuous monitoring of Sulfur dioxide (SO2) in ambient air
		COMPOSITION
		Main unit : 1 set
		Rack mount with chassis slides : 1 set
		Internal Zero Span valves with permeation tube
		: 1 set
		SPECIFICATIONS
		Measurement method : UV Fluorescent
		Ranges : 0-50 ppb to 0-20,000 ppb selectable in 1
		ppb instruments.
		Noise at Zero : Less than .2 ppb RMS
		Lower Detectable Limit : Less than .4 ppb RMS
		Zero Drift : <1 ppb/7 days
		Span Drift : <1% of reading/7 days
		Response Time : 20 seconds
		Linearity : 1%
		Approved Temperature Range : 5-40 degree C
		Safe Operating Temperature Range : 0-50 degree C
		Analog Output : 100 mV, 1V, 5V, 10V
		Digital Output : RS-232 and status outputs shall provide isolated
		contact closures for zero cal and span cal
		operation, as well as fault conditions for
		instrument flow, temperature, system power,
		high voltage and UV lamp.
		In addition, a "system okay" indication shall be
		provided as a status output.
		Mounting : 19 inch rack
		FEATURES:
		Internal permeation oven at 50 degree C output with permeation tube .4 ppm output.
		Internal zero air source.
		Internal pump.
		2 year lamp life.
		An in-line particulate filter with visual indication of condition of filter element
		without disassembly shall be included. Must be accessible from front panel.
		Shall contain ability to view and store one week of 30 min. averages. Averages can
		be set for 1 to 60 minutes.
		Software and set-up parameters shall be stored in non-volatile memory.
		Shall provide Diagnostic warning messages on front panel and through serial port
		in case of out of tolerance of key parameters.
		ACCESSORIES : According to other manufacturer's standard
		Digital output cable with RS-232 : 10 m
		between monitor and data logger
		Analog output cable between monitor : 3 m
		and recorder
		TPFE tube between monitor and : 1/4", 3 m
		manifold
		SPARE PARTS AND CONSUMABLES
		Expendables for 1 year : 1 set
		(Filter TFE 37mm 50pcs., Sintered SS Filter 6pcs., Spring Flow Control 2pcs.,
		Oring Flow Control 12pcs., Activated Charcoal 2pc., Filter DFU 2pcs., Oring Perm Oven 4pcs.)
		Spare parts for 1 year : 1 set
		(UV lamp 1pc., UV filter 214nm 1pc., Pump Rebuild Kit KNF 1pc., Solid State Relay 12VDC 1pc.)
		SO2 permeation tube : 1 pc.

Table 6.17 (2) Example of the Specification (NOx Analyzer)

No.	Item	Specification
1-1-2	NOx Analyzer	APPLICATION
		Chemiluminescent NO/NO2/NOx Analyzer
		COMPOSITION
		Main unit : 1 set
		Rack mount with chassis slides : 1 set
		Internal Zero Span valve : 1 set
		SPECIFICATIONS
		Measurement Method : Chemiluminescent
		Ranges : 0-50 ppb to 0-20,000 ppb selectable in 1 ppb increments.
		Noise at Zero : < .2 ppb RMS
		Lower Detectable Limit : < .4 ppb RMS
		Zero Drift : < 1 ppb/7 days
		Span Drift : < 1% of reading/7 days
		Linearity : 1%
		Approved Temperature Range : 5-40 degree C
		Safe Operating Temperature Rauge : 0-50 degree C
		Analog Output : 100 mV, 1V, 5V, 10V
		Digital Output : RS-232 and status outputs shall provide isolated contact closures for zero cal and span cal operation, as well as fault conditions for instrument flow, temperature, system power high voltage power. In addition, a "system okay" indication shall be provided as a status output.
		Mounting : 19 inch rack
		FEATURES
		Ozone and sample flows controlled by temperature stabilized critical orifices.
		Sample and ozone flowrates as well as reaction cell pressure to be digitally displayed on front panel.
		Software shall automatically compensate for ambient pressure and reaction cell (vacuum) pressure.
		Unit shall include internal permapure dryer for ozone generator air supply.
		Instrument shall use internal auto-zero system which continuously corrects for zero drift automatically.
		Shall automatically change time constant to optimize response time.
		Shall include thermal ozone destruct unit and charcoal ozone scrubber prior to the pump to prevent ozone and oxides of nitrogen venting into room and to protect the pump and extend life of charcoal scrubber.
		An in-line particulate filter with visual indication of condition of filter element without disassembly shall be included. Must be accessible from front panel.
		Shall contain ability to view and store one week of 30 min. averages. Averages can be set for 1 to 60 minutes.
		Software and set-up parameters shall be stored in non-volatile memory.
		Shall provide Diagnostic warning messages on front panel and through serial port in case of out of tolerance of key parameters.
		ACCESSORIES : According to other manufacturer's standard
		Digital output cable with RS-232 between monitor and data logger : 10 m
		Analog output cable between monitor and recorder : 3 m
		TPFE tube between monitor and manifold : 1/4", 3 m
		SPARE PARTS AND CONSUMABLES
		Expendables for 1 year : 1 set
		(Gasket 8pcs., Filter TFE 37mm 50pcs., Activated Charcoal 2pcs., Fuse O3 1A 8pcs., Sintered Filter 8pcs., Filter DFU 4pcs., Spring Flow Control 4pcs., Oring Flow Control 16pcs., Purafil 6LBS 2pcs.)
		Spare parts for 1 year : 1 set
		(Heater Reaction Cell 12W 1pc., Pump Rebuild Kit 1pc., Solenoid Valve SS 12V 1pc.)

Table 6.17 (3) Example of the Specification (CO Analyzer)

No.	Item	Specification
1-1-3	CO Analyzer	APPLICATION
		Continuous monitoring of Carbon monoxide (CO) in ambient air
		COMPOSITION
		Main unit : 1 set
		Rack mount with chassis slides : 1 set
		Stainless steel valves for zero/span gas : 1 set
		SPECIFICATIONS
		Measurement Method : IR Gas Filter Correlation
		Ranges : 0-1 ppm to 0-1,000 ppm selectable in 1 ppm
		increments.
		Noise at Zero : < .025 ppm RMS
		Lower Detectable Limit : < .05 ppm RMS
		Zero Drift : < .2 ppm/7 days
		Span Drift : < 1% of reading/7 days
		Linearity : 1%
		Approved Temperature Range : 5-40 degree C
		Safe Operating Temperature Range : 0-50 degree C
		Analog Output : 100 mV, 1V, 5V, 10V
		Digital Output : RS-232 and status outputs shall provide isolated
		contact closures for zero cal and span cal
		operation, as well as fault conditions for
		instrument flow, temperature, system power.
		In addition, a "system okay" indication shall be
		provided as a status output.
		Mounting : 19 inch rack
		FEATURES
		Unit shall be supplied with replicated field and objective mirrors without adjustment
		screws and shall never need adjustment even after cleaning.
		Gas Filter Correlation wheel shall be constructed of sapphire and covar to prevent leaks. Shall
		have 5-year warranty.
		Measurement shall be temperature and pressure compensated.
		An in-line particulate filter with visual indication of condition of filter element
		without disassembly shall be included. Must be accessible from front panel.
		Shall contain ability to view and store one week of 30 min. averages. Averages can
		be set for 1 to 60 minutes.
		Software and set-up parameters shall be stored in non-volatile memory.
		Shall provide Diagnostic warning messages on front panel and through serial port
		in case of out of tolerance of key parameters.
		ACCESSORIES : According to manufacture
		Digital output cable with RS-232 : 10 m
		between monitor and data logger
		Analog output cable between monitor : 3 m
		and recorder
		TPFE tube between monitor and : 1/4", 3 m
		manifold
		SPARE PARTS AND CONSUMABLES
		Expendables for 1 year : 1 set
		(Filter TFE 37mm 50pcs., Pump Diaphram KNF 2pcs.)
		Spare parts for 1 year : 1 set
		(Orifice 13 MIL 2pcs., Thermistor Assy 1pc., Assy Heater/Thermistor 1pc., Source Assy 1pc.)

Table 6.17 (4) Example of the Specification (O_3 Analyzer)

No.	Item	Specification
1-1-5	O3 Analyzer	APPLICATION
		Continuous monitoring of Ozone (O3) in ambient air
		COMPOSITION
		Main unit : 1 set
		Rack mount with chassis slides : 1 set
		Internal ozone generator with feedback : 1 set
		detector zero air source and
		fluorocarbon valves
		SPECIFICATIONS
		Measurement Method : UV absorption
		Ranges : 0-50 ppb to 0-20,000 ppb selectable in 1 ppb increments.
		Noise at Zero : < .3 ppb RMS
		Lower Detectable Limit : < .6 ppb RMS
		Zero Drift : < 1 ppb/7 days
		Span Drift : < 1% of reading/7 days
		Linearity : 1%
		Approved Temperature Range : 5-40 degree C
		Safe Operating Temperature Range : 0-50 degree C
		Analog Output : 100 mV, 1V, 5V, 10V
		Digital Output : RS-232 and status outputs shall provide isolated
		contact closures for zero cal and span cal
		operation, as well as fault conditions for
		instrument flow, temperature, system power.
		In addition, a "system okay" indication shall be
		provided as a status output.
		Mounting : 19 inch rack
		FEATURES
		Flow should be controlled by critical flow orifice.
		Concentration measurement shall be temperature and pressure compensated.
		Optical bench lamp shall be temperature controlled to eliminate the effects
		of humidity.
		Flow rate through the analyzer to be digitally displayed on front panel display.
		Shall contain an internal ozone generator with separate feedback detector shall
		automatically measure and correct for changes in the lamp intensity through the
		microprocessor controlled feedback loop.
		Shall contain built in zero air.
		Temperature and current controlled lamp.
		An in-line particulate filter with visual indication of condition of filter element
		without disassembly shall be included. Must be accessible from front panel.
		Shall contain ability to view and store one week of 30 min. averages. Averages
		can be set for 1 to 60 minutes.
		Software and set-up parameters shall be stored in non-volatile memory.
		Shall provide Diagnostic warning messages on front panel and through serial port
		in case of out of tolerance of key parameters.
		ACCESSORIES : According to other manufacturer's standard
		Digital output cable with RS-232 : 10 m
		between monitor and data logger
		Analog output cable between monitor : 3 m
		and recorder
		TPFE tube between monitor and : 1/4", 3 m
		manifold
		SPARES AND CONSUMABLES
		Expendables for 1 year : 1 set
		(Filter TFE 37mm 50pcs., Sintered SS Filter 6pcs., Spring Floe Control 2pcs.,
		Oring Flow Control 4pcs., Pump Rebuild Kit 4pcs., Activated Charcoal 2pc., Pads 4pcs.,
		Filte DFU 2pcs.)
		Spare parts for 1 year : 1 set
		(Orifice 13MIL 1pcs., Absorption Tube 1pcs., Assy Heater/Thermistor 1pcs.,
		Internal Ozone Scrubber 2pcs., Pump Rebuild Kit 2pcs.)

Table 6.17 (5) Example of the Specification (SPM Analyzer)

No.	Item	Specification
1-1-6	SPM Analyzer	APPLICATION
		Continuous monitoring of PM-10 in ambient air
		COMPOSITION
		Control unit : 1 set
		Sensor Unit : 1 set
		Interconnecting Cable : 1 set
		Sample Inlet and Tubing : 1 set
		SPECIFICATIONS
		Measurement Method : Filter-based direct mass measurement using microbalance
		(or tapered element oscillating microbalance)
		Noise at Zero : < +5 micro-g/m3 for one-hour average
		Lower Detectable Limit : < 0. 1 micro-g/m3 for one-hour average
		Precision : < 2 micro-g/m3 for one-hour average
		Data Output : Continuous, updated every 2 seconds
		Data Averages : 30 minute, 1 hour, 8 hour and 24 hour
		Calibration Verification : Using gravimetric mass of calibration insert
		Approved Temperature Range : 2 to 40 degree C
		Ambient Temperature Range : -40 to + 60 degree C
		Analog Output : 3 user-defined outputs
		0-1, 0-2, 0-5 or 0-10 VDC
		Digital Output : RS232 and states outputs shall provide information
		concerning flow, temperature, loading and mass
		transducer operation. Two user-defined contact
		closures for states conditions.
		Mounting : Built in 19 inch rack for control unit, counter
		top for sensor unit
		Other necessary utility : Constant-temperature heating of sample steam
		to avoid condensation
		FEATURES
		Direct mass measurement using continuous inertial mass measurement.
		Optional addition of an 8-channel conditional particulate sampling system.
		Active volumetric flow rate maintained through the use of mass flow controller
		and adjustment for measured ambient temperature and pressure.
		Shall contain the ability to view and store up to 40 weeks of 30 min. averages.
		User-defined averages can be set for 5 sec. To 60 min.
		Software and setup parameters shall be stored in non-volatile memory.
		Shall provide diagnostic warning messages on front panel and through serial port
		in case of out of tolerance of key parameters.
		ACCESSORIES : According to customer requirements.
		Digital output cable with RS-232 between : 10 m
		calibrator and data logger
		TPFE tube between calibrator and : 1/4", 3 m
		monitor
		Tubes between calibrator and standard : 1/4", 10 m 2pcs
		gas cylinder
		SPARES AND CONSUMABLES
		Expendables for 1 year : 1 set of Average Annual Consumables Pack
		Spare parts for 1 year : 1 pump rebuild kit (every 15 months on average)

Table 6.17 (6) Example of the Specification (Wind Direction and Speed Equipment)

No.	Item	Specification	
1-2 Meteorology			
1-2-1	Wind Speed Direction		
	Equipment	APPLICATION	
		Continuous monitoring of wind speed and wind direction	
		COMPOSITION	
		Ultrasonic wind sensor with heater	: 1 unit
		Sensor cable	: 1 set
		Fixed metal fitting for pole	: 1 set
		SPECIFICATIONS	
		Type	: Ultrasonic wind sensor or equivalent
		Measuring range	: 0 to 60 m/s, 0 to 360 degrees
		Accuracy	
		Wind speed	: 3 %
		Wind Direction	: 2 degrees
		Resolution	
		Wind speed	: 0.1 m/s(starting wind speed 0.1 m/s)
		Wind Direction	: 1 degree
		Operating Temperature	: Approx. -30 to +50 degree C
		Sensor cable	: Connect with the translator 15m
		ACCESSORIES	
		Manufacturer's Standard Accessories	: 1 set
		Digital output cable with RS-232	: 10 m
		between monitor and data logger	
		Analog output cable between monitor	: 3 m
		and recorder	
		SPARE PARTS & CONSUMABLE	
		Manufacturer's Standard Accessories	: 1 set

Table 6.17 (7) Example of the Specification (Container)

No.	Item	Specification	
1-3-7	Container	APPLICATION	
		Container for Monitoring System	
		COMPOSITION	
		Container	: 1 unit
		Pole with flange for anemometer	: 1 set
		Arrestor	: 1 set
		Switchboard	: 1 set
		Power supply board	: 1 set
		19 inch rack for Analyzer and Recorder	: 2 sets
		Table, chair	: 1 set
		Earth plate and earth wire	: 1 set
		SPECIFICATIONS	
		Container	
		Dimension	: Reference for Appendix
		Power supply	: Reference for Appendix
		Material	
		Outer wall	: Steel or Aluminum
		Heat insulator	
		Side board	: Glass wool(More than 50mm) or equivalent
		Roof board	: Glass wool(More than 80mm) or equivalent
		Inner wall	: Wood panel
		Window	: None
		Door	: With alarm for intruders
		Switchboard	: Attachment on inner wall x 2 pc. (3 kVA respectively)
		Ventilating fan and louver	: 1 pc.
		Air conditioner(cooler and heater)	: 1 pc. 2.7kVA or more
		Lighting	: 2 pc. Fluorescent lamp(2 x 40W)
		Wall socket	
		On the ceiling for analyzers	: 5 x 2pc.
		On the wall for air conditioner	: 1 x 1pc.
		On the wall for telemeter system	: 5 x 1pc.
		On the wall for services	: 3 x 1pc.
		Ladder	: 1 pc.
		Rack for 2 cylinders 50L(dia. 240mm)	: 1 pc.
		Pole(with stay and foothold)	
		Dimension	: Reference for Appendix
		Length	: 10 m for ground level
		Diameter	: Approx. 60 mm
		Material	: Aluminum or duraluminn
		Flange	: For anemometer and temperature and hygrometer
		Arrestor	
		Rated voltage	: 230 V
		Operating start voltage	
		line interval	: 470 V (+ 10%)
		Ground interval	: 500 V (+ 12%)
		Limiting voltage	
		Discharge current 1500 A(8/20 micro-sec)	
		line interval	: Less than 1100 V
		Ground interval	: Less than 1100 V
		Operating duty 1500 A(8/20 micro-sec)	
		Same polarity	: 5 times
		Inverse polarity	: 5 times
		Discharging current	
		line interval(8/20 micro-sec)	: 4 kA 2 times
		Ground interval(4/10 micro-sec)	: 15 kA 2 times
		19 inch rack	: Open type
		Material	: Steel or equivalent
		Height	: 2000 mm
		ACCESSORIES	
		Manufacturer's Standard Accessories	

3) Presentation of Estimate and Preparation of Estimated Price

The estimate of the air pollution monitoring system includes the local transportation, installation and adjustment and necessary training as well as the equipment and materials itself.
The estimate conditions are summarized roughly as follows:

- Guarantee of spare parts and consumable items for the two-year operation taking into consideration the air pollution and meteorological conditions of Macedonia
- Delivery of equipment and materials at the specified place
- Clear definition of the delivery limit and the installation/adjustment period in the estimate
- Installation work of the equipment/materials including auxiliary works (electricity, fence, etc.)
- The warranty period of equipment/materials is to be one year or more after acceptance
- Training is to be provided twice for the specified principal equipment/materials
- Periodic inspection is to be made twice during the warranty period and once in six months after expiration of the warranty period for the specified equipment/materials
- Clear designation of accessories included in the main body and those not included

Various expenses necessary for the above must be described in the estimate, separately from the price of the main body. It is also necessary to indicate the purchase price of the equipment/materials either on the basis of EX-GODOWN, FOB, or CIF.
The estimated price and bidding documents must be prepared after thorough study on the result of estimate presentation and the previous price by each equipment/material item.
The estimated price is prepared for the purpose of establishing the judgment criteria to enable purchase with advantageous prices as much as possible, as well as review of the project budget. Preparation of the estimated price requires especially careful attention so as not to exert an adverse effect on the subsequent implementation of the bidding, the contract, delivery and inspection.

(2) Bidding

1) Bidding Procedures

International financial institutions consider that, in most cases, International Competitive Bidding (ICB) is the best method for achieving the economical and efficient procurement of equipment and materials. The following methods other than

ICB to be followed for the procurement of equipment and materials are generally specified in the loan agreement between the borrower and the financial institution:

- Limited international bidding (LIB)
- Local competitive bidding (LCB) to the local portion
- International shopping
- Direct contracting

2) Prequalification of Bidders

Prequalification is advisable for large or complex works and, exceptionally, for custom-designed equipment and specialized services to ensure, in advance of bidding, that invitations to bid are extended only to those who are capable. Prequalification should be based entirely upon the following capability of prospective bidders to perform the contract satisfactorily:

a) Qualification

- Experience of and past performance on similar contracts
- Capabilities with respect to personnel, equipment and plan
- Financial position

b) Technical Level

In addition, the bidder must have a certain technical level. Evaluation details in the technical level are as follows:

- Installation, adjustment and training plan after delivery
- Details and system of the after-sales service, including maintenance during the warranty period
- System for the supply of parts, etc.
- Countermeasures in case of a failure (the number of days required, the presence of the agent in Macedonia or neighboring countries)
- Details and costs of a maintenance service agreement when this is necessary after expiration of the warranty period
- Technical countermeasures proposed by the contractor for meteorological conditions, etc. at the time of selection of the equipment and materials

3) Two-stage Bidding

In the case turnkey contracts or contracts for large complex works of a special nature, it may be undesirable or impractical to prepare complete technical specifications in advance. In such a case, a two-stage bidding procedure may be used, under which first unpriced technical proposals on the basis of a conceptual design or performance specifications are invited, to be followed by priced bids in the second stage.

4) Bidding Documents

The bidding documents should provide all information necessary to enable a prospective bidder to prepare his bid for the goods and services to be provided. While the detail and complexity of these documents will vary with the size and nature of the proposed bid package and contract, they should generally include the followings:

- Invitation of bid
- Instructions to bidders
- Form of bid
- Form of contract
- Conditions of contract (both general and special)
- Technical specifications
- List of goods or bill of quantities and drawings
- Necessary appendices
- Detailing, for example, the type of security

5) Selection of Successful Bidder

General procedures from the bidding to the award of contract are as follows:

- Opening of bids
- Examination of bids
- Evaluation and comparison of bids
- Preparation of evaluation report
- Award of contract

6) Inspection and Commissioning

a) Factory Inspection

The manufacturer must conduct the performance test before shipment and prepare the

test result while making adjustments so that the installed equipment complies with the requirements of the specification. Subsequently, the factory inspection must be made on the principal equipment and materials.

b) Pre-shipment Inspection when Required

c) Unpacking Inspection of Equipment and Materials Delivered at Site

After delivery to the specified place, the equipment and materials must be unpacked and thoroughly checked with regard to quantity and damage of the packaging or equipment/materials caused during transport. The principal items to be checked are the following:

- Check of the quantity of the equipment/materials and the standard accessories, spare parts and additional accessories
- Check of the nameplate which indicates the name, serial number and date of manufacture, the power supply, etc., for the equipment and materials
- Confirmation that the inspection has been completed when an export inspection, etc. is necessary.
- Confirmation of the content and quantity of the necessary items to be submitted, including the operating manual, etc..

The result of the unpacking inspection is summarized on the specified acceptance sheet.

d) Performance Test

After installation of the equipment and materials, an inspection must be made to determine whether or not the performances comply with the specification.
The final acceptance becomes effective when there is no problem with the performance, everything including the system and software is functioning properly, and when the monitoring starts. It is to be noted that the acceptance is rejected, with the requirement that improvement or replacement be made, when the description of the specification or the contents of test result is not complied with. On the other hand, the equipment and materials are judged to be acceptable when their performance, quality, etc., are superior to the performance stipulated in the specification and do not present any practical problem. The acceptance result is summarized on the acceptance sheet.

7) Training

Training for the routine operation, maintenance and trouble shooting should be provided for the operational staff members by the manufacturer, local agent and/or supplier. The training may be categorized into the followings:

a) Training at the manufacturers premises, prior to installation, when required
b) Training after installation at the site
   - First training: Mainly concerned with handling of the monitoring equipment
   - Second training: Overall training on maintenance and minor repair of the equipment and materials

8) Maintenance

The scope of the contract includes the duty of periodical inspections, a total of three times, for a period of 18 months for the specified equipment/materials. It is desirable to conclude the maintenance agreement for the equipment/materials subsequently with the manufacturer or agent.

Considering the maintenance and troubleshooting for the procured monitoring system, it is important factor to select the manufacturer which have the local agent. One of options to maintain the monitoring system after the taking over the equipment and materials is outsourcing to the local agent.