Appendix 10-1

TECHNICAL GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT ON AIR POLLUTION BY THERMAL POWER PLANTS DURING OPERATION (FRAMEWORK)

1. Major Air Pollution by Thermal Power Plant Operation

Combustion, storage, handling and transportation of fuel or ash are the major activities which will give potentially significant impacts on air quality during the thermal power plant operation. The major air pollutants generated by these activities include sulfur dioxide, nitrogen dioxide and particulate matter. Sulfur dioxide comes from combustion of sulfur in the fuel. Nitrogen dioxide is generated from combustion of nitrogen in the fuel and in air for combustion. Particulate matter consists of particulate (soot, ash, etc.) generated by combustion and dust generated or littered by storage, handling or transportation of fuel or ash.

2. Scope of Environmental Impact Assessment (EIA) for Air Pollution

(1) Target Pollutant

Target air pollutants in this guideline are emitted or littered by or for the thermal power plant operation (Operation). They are selected from the following pollutants according to the kind (fuel and power generation type), scale of the Operation, and the general condition of the region where the Operation is carried out.

- Sulfur dioxide (SO_2)
- Nitrogen dioxide (NO_2)
- Particulate matter (particulate)
- Particulate matter (dust)

Generally speaking, the air pollutants which shall be taken into environmental consideration depend on the nature of the power plant as shown in **Table 1**.

(2) Target Stage

Operation stage of the power plant is targeted in this Guidelines.

Table 1 Fuel Kind , Plant Type and Air Pollution

(thermal power stations)

Plant type	Fuel type	Air pollution: Sulfur dioxide	Air pollution: Nitrogen dioxide	Air pollution: Particulate matter
Steam	Fuel oil	◎	○	○
	Gas oil	○	○	△
	Natural gas		○	
	Coal	◎	◎	◎
Gas turbine	Natural gas		◎	
	Gas oil	○	◎	△
Combined cycle	Natural gas		◎	
	Gas oil	○	◎	△
Internal combustion engine	Fuel oil	◎	◎	○
	Gas oil	○	◎	△

Note ◎ : Potentially significant impact
○ : Potentially certain impact
△ : Potentially non-significant impact

(3) Target Area

The target area is, in principle, the surrounding area within 15 ~ 25 km from the Operation site. However, the area shall be determined based on the expected maximum ground level concentration, the distance between the stack and the point where the maximum concentration appears, and the general condition of the region where the Operation is carried out. The former two values can be approximately calculated by a plume model (see **Article 5. of this Appendix 10-1**) with given emissions and meteorological conditions.

3. Data Collection

In order to know the current quality of ambient air and to predict and evaluate the environmental impacts due to the Operation, necessary data have to be collected in due consideration of the scale of the Operation and the general condition of the surrounding area.

- Air quality
- Meteorology
- Topography and sizes of buildings
- Land use
- Stationary pollutant sources
- Vehicle traffics

- Laws and regulations

(1) Air Quality

1) Survey Pollutant -- The pollutants to be surveyed are the selected target air pollutants. In case nitrogen dioxide is selected as a target pollutant, nitrogen monoxide has to be surveyed as well.
2) Survey Item -- Air pollutant concentration
3) Survey Area -- The target area
4) Survey Method -- Collection of existing data or field survey shall be conducted. In case existing data are not sufficient for the survey items, field surveys are required.
5) Survey Period -- Considering meteorological conditions, etc., survey periods shall be determined so as to have a correct understanding of the air quality throughout a year. If possible, yearly air quality changes in recent years shall also be collected.
6) Survey Point -- In order to know properly the air quality in the area, survey points shall be decided in consideration of the general condition, etc. of the area.
7) Measuring Method -- Follow the methods stipulated by the relevant laws, etc.
8) Chemical Analysis Method -- Follow the methods stipulated by the relevant laws, etc.
9) Field Survey
   a) Survey Period -- The survey periods shall be enough to know the air quality change throughout a year. Periods and frequencies of the survey shall be reflected from the scale of the Operation, and change patterns of the air pollutant concentrations, meteorological parameters and industrial operations, etc. in the area. Cooperation of local communities in the area is mandatory for the survey.
   b) Survey Point
      a. The survey points shall be determined, by keeping the following in mind:
         - Select the points which are expected to receive no influence of any other specific air pollutant sources than the sources of the power plant and will give an accurate understanding of the air quality in the area.
         - Select the points where high concentrations will occur due to the Operation or points close to them.
      b. Air sampling points shall be determined at the height where people usually live and breathe; in principle, 1.5 m to 10 m above the ground.
         The sampling points of SPM shall be selected in consideration of influences of dust raised from the ground, etc.
   c) Measurement Method -- Follow the methods stipulated by the relevant laws, etc.
   d) Chemical Analysis Method -- ditto
   e) Storage of Samples -- Samples for chemical analysis shall be kept in good

condition so as not to change their property before their analyses.

(2) Meteorology

The following meteorological parameters have to be observed and they are used to analyze the current state of air pollution and to predict air quality change due to the Operation.

1) Survey Item
   a) Climate
      a. Temperature
      b. Precipitation
      c. Humidity
      d. Wind
      e. Sunshine
      f. Others
   b) Surface Meteorology
      a. Wind direction and wind speed
      b. Solar radiation
      c. Net radiation
      d. Temperature
   c) Upper Meteorology
      Upper meteorology has to be observed where the plant has high stacks (>100m).
      a. Upper wind direction and wind speed
      b. Vertical temperature distribution
2) Survey Area -- the target area
3) Survey Method -- Collection of existing data or field survey shall be carried out. In case existing data are not enough for the survey items, field surveys have to be conducted. Collected existing data should represent the meteorology in the survey area. However, existing data on points outside the survey area are applicable if they can be considered as to represent the meteorology in the area.
4) Survey Period -- Follow the survey period for the air quality survey.
5) Survey Point -- The survey points shall be selected so as to give a correct understanding of the meteorological parameters necessary for analysis of the air pollution and prediction of the change of the air quality in the area.
6) Observation Method -- Follow the methods shown in the field survey below.
7) Field Survey
   a) Observation Period
      a. Surface Meteorology -- In principle, surface meteorology shall be

continuously observed throughout a year. However, period and frequency of the observation are determined according to the general state of the air quality in the area so long as the observation can give a correct understanding of the meteorological change throughout a year.

b. Upper Meteorology -- Upper meteorology is observed for about one week (3 days ~ 2 weeks) in each season. The observation can be stopped during unusual weather like rain or strong wind.

b) Observation Point -- The observation points shall be decided in consideration of the general meteorological condition in the area, with the following remarks;

- In case the topography, buildings, meteorology, etc., are likely to generate a special local phenomena, observation points shall be determined to know the situation.
- To observe the representative wind in the area, points free from the influences of the local topography and buildings shall be selected.

c) Observation Method -- Follow the observation methods specified by National Weather Bureau or equal to them. Wind direction and wind speed are in principle the respective averages in 10 minutes just before the hour.

(3) Topography and Buildings

Surrounding topography (ups and downs, slopes, etc.) and buildings (size and location of buildings, etc.) have to be surveyed, because they are expected to cause locally complicated air current and to influence advection and diffusion of air pollutants. If the topography and buildings are expected to have a significant change in the future, it shall be surveyed as well.

1) Survey Method -- Existing data such as topographical maps or field surveys shall be collected. In case the existing data are not sufficient, field surveys are conducted.

2) Survey Area -- the area for air quality survey

(4) Land Use

Land uses (agricultural land, forest, river, road, school, factory and business establishment, house, etc.) are surveyed, if the land uses of individual districts are designated by a City Planning Law or else. Distribution of schools, hospitals, etc. which are expected to be susceptive to air pollution shall be surveyed. Land use in the future shall be surveyed as well.

1) Survey Method -- Existing data such as maps on land uses and city planning information shall be collected. If the existing data are not sufficient, data shall be collected

in the field.

2) Survey Area -- the area for air quality survey

(5) Stationary Pollutant Sources

Locations of main factories and business establishments, and their air pollutant emission characteristics, and also their future trends shall be surveyed. Damages caused by air pollution and complaints on air pollution in the area shall be surveyed as well.

1) Survey Method -- collection of existing data
2) Survey Area -- the area for air quality survey

(6) Vehicle Traffics

The following surveys have to be carried out for motor vehicles.

1) Survey Item -- traffic volume and vehicle type
2) Survey Roads -- Based on the expected traffic flow and traffic volume associated with the Operation, the roads around the Operation site and the roads linked with them shall be mainly surveyed.
3) Survey Method -- collection of existing data

(7) Laws and Regulations

Information on air quality standards, emission standards, etc. are to be collected.

4. Current Environment

(1) Air Quality

Collected data have to be statistically processed and analyzed into items given below. Characteristics of the survey points (the surrounding topography and buildings, air pollutant sources nearby, sampling conditions, etc.) shall be considered in the analysis.

1) Statistically Processed Results
   a) Automatic and Continuous Monitoring Stations
      - Numbers of effectively measured hours and days in a year
      - Annual average, monthly averages and their fluctuation pattern

- Time-zoned averages and their fluctuation pattern
- Maximum one-hour value
- Compliance with environmental standards
- Integrated concentration curve
- Average concentrations by wind direction

b) Monitoring by Simple Methods -- Seasonal averages and their fluctuation pattern

2) Analysis -- Air quality, relations between air quality and meteorology, and high concentration state are analyzed based on the statistically processed results.

3) Damages by Air Pollution -- Damages to health, plants, etc. due to air pollution, or their complaints are summarized.

(2) Meteorology

The characteristics of the climate of the area have to be summarized. Items as shown below are obtained with statistical process and analysis.

1) Statistically Processed Results

a. Surface Meteorology

- Wind rose by season and time zone
- Appearance frequency of wind direction and wind speed by season and time
- Appearance frequency of atmospheric stability by season, time zone, wind direction and wind speed
- Others -- meteorological parameters for prediction of a short-term concentration (if necessary)

b. Upper Meteorology

- Wind direction, wind speed and temperature by season and altitude
- Inversion layer by season and time zone

2) Analysis -- Surface wind, upper wind and appearance of inversion layer are examined based on the statistically processed results.

(3) Topography and Buildings

The extent of the influence of the surrounding topography and buildings on the air dispersion has to be examined in order to use for selection of prediction methods.

(4) Land Use

The current and future land uses in the area have to be realized for evaluation of the impact by the Operation.

(5) Air Pollutant Sources

Information on emissions of major sources and distributions of the pollutant sources in the area has to be summarized.

(6) Vehicle Traffics

Traffic volume and vehicle type around the Operation site are also to be summarized.

(7) Laws and Regulations

Air quality standards, emission standards, environmental targets, etc. established by national and local governments are compiled for evaluation of the impact by the Operation.

5. Future Prediction

(1) Prediction Item

Prediction items are the pollutants' emission rates and their concentrations in, or littered and falling volumes from the ambient air due to the addition of the Operation. These shall be predicted in a long-term average. A short-term average can be predicted as well, if required and possible.

Predicted items are as follows.

1) Predicted Pollutant -- The selected target pollutants
2) Predicted Concentration -- Predicted is the additional emission and concentration on the environment due to the addition of the Operation.
3) Predicted Base -- The prediction is, in principle, based on a long-term average (annual average). In case the emission conditions, etc. of a pollutant seem not to be constant and remarkably change throughout a year, adequate prediction periods (averaging period) such as seasons shall be selected for the pollutant, and the average concentration in these periods shall be predicted as the long-term average.

   In case high pollutant concentrations due to one or combinations of the following are expected to occur in consideration of the scale of the Operation, short-term averages (short-term high concentrations) shall be predicted. The short-term average is, in general, based on one-hour. However, the averaging period can be changed as needed.

- Especially unfavorable conditions like inversion layers
- A complicated topography around the Operation site
- Possibility of down-wash or down-draft due to the surrounding buildings, etc.
- Other conditions causing high concentrations

(2) Predicted Time

Prediction time has to be determined at a time when the Operation is expected to be in normal after the construction work is over. In case the facilities, etc. of the plant are to start operation step by step, the air quality at each step shall be predicted as a rule.

(3) Predicted Area

The predicted area is the survey area. The predicted points shall be determined by referring to the survey points of the current conditions and its height is to be around 1.5m from the ground for the gaseous pollutants. However, prediction at a higher level is necessary if the structure of the power plant and the heights of the surrounding buildings request so.

(4) Prediction Method

One or combinations of the following methods shall be selected for the prediction of ambient air quality in view of the scale of the Operation, fuel types, and the surrounding topography and buildings.

- Air dispersion equation
- Similar experience
- Other suitable method

A general procedure for the prediction of air quality by an air dispersion equation is as follows.

1) Prediction of Annual Average Concentration

(a) Steps for Air Dispersion Simulation

Steps for a numerical simulation of an annual average concentration by an air dispersion equation are as following;

a. Classify the meteorological parameters (wind direction, wind speed and atmospheric stability), and prepare their frequency tables by season and time zone.

b. Determine the air pollutant emission rates and stack dimensions.

c. Simulate the air pollutant concentration due to the Operation under the above conditions.

d. Calculate the environmental concentration from the simulated results, etc.

(b) Choice of Simulation Model

The basic simulation model is the Gaussian diffusion models (Plume model for windy condition and Puff model for calm condition). However, other suitable models than the Gaussian models can be selected in consideration of the purpose of the simulation, stack condition, diffusion field, available information on the diffusion field, etc. In such a case, it is necessary to explain the reason why the specific model is chosen and the way how calculation conditions are determined.

In case the scale of the Operation necessitates checking the applicability of the Gaussian diffusion model, it is desirable to verify the model itself and diffusion parameters by similar experiences, etc.

Models used for gaseous pollutants are also applicable to suspended particulate matter (the particulate whose particle size is less than 10μ).

(c) Prediction Condition

It is necessary to clarify the prediction conditions before calculation. They shall be established by keeping the following points in mind;

a. Effective Stack Height

If an effective stack height is estimated, it is necessary to confirm whether the exhaust gas can rise without influences of surrounding buildings, etc. If it can rise without these influences, the following equations can be used in principle, keeping the conditions of the emission from the stack, meteorology, etc. in mind.

<u>Windy condition</u>:	• CONCAWE equation
	• Briggs equation
<u>Calm condition</u>:	• Briggs equation

b. Air Pollutant Emission

The amount of an air pollutant emission is estimated from the fuel consumption, suitable emission factor, etc. based on the power plant design. If the emission is expected to fluctuate, adequate emissions by season and time zone shall be determined in consideration of the fluctuation pattern.

c. Meteorological Parameter

The wind direction, wind speed and atmospheric stability are classified (modeled) respectively in order to prepare their frequency tables by season and time zone. A power-function type equation is applicable, in case it is necessary to estimate the upper wind speed.

(d) Additional Concentration due to Operation

A concentration of each pollutant is calculated under each classified set of the meteorological parameters and the emission rate. It is summed with weighing each occurrence ratio of each classified set into the annual average concentration.

(e) Estimation of NO_2 Concentration from NOx Concentration

The air quality standard for nitrogen oxides is for NO_2. However, unlike SO_2, NO_2 concentration can not usually be calculated directly, due to change of NO into NO_2 during diffusion of NO. Hence, to judge the compliance with the standard of NO_2, the concentration of NO_2 must be estimated (converted) from the concentration of NOx. There are three types of conversion models: a statistical model, a stationary approximation model and a exponential approximation model.

(f) Ambient Concentration

The ambient concentration of each pollutant at each point is calculated by summing the additional concentration due to the addition of the Operation on the current concentration at the point.

6. Impact Evaluation

(1) Evaluation Item -- The evaluation items are the same as the predicted items.

(2) Evaluation Method

Impact of the Operation on the environment (human beings, plants, animals, national heritage, monuments, properties, materials, etc.) shall be evaluated in consideration of the regional characteristics, adopted environmental mitigation measures and indices of evaluations.

(3) Evaluation Indices

Indices for impact evaluation are as shown below.

a. Air quality standard
b. Emission standard
c. Environmental target
d. Other scientific knowledge on influences of air pollution on human health, plants, animals, agriculture, materials, etc.

In case of pollutants whose air quality standards are not registered by the annual average but by shorter-term ones, their impacts can be evaluated by either of the following ways.

a. Derive a relationship of an annual average concentration with the value corresponding to the designated shorter-term average, from air quality data measured under similar conditions to those of the area where the Operation is carried out. The converted value based on the relationship is compared with the standard value.
b. By the similar fashion to the above, the standard value is converted into the

corresponding annual average, and the converted value is compared with the predicted annual average value.

When the above methods are used, it is necessary to show the validity of the selected area for the derivation of the relationship: similarity of topography and meteorology between the two areas.

In case short-term concentrations are predicted, their impacts have to be evaluated based on their appearance frequency in a year and corresponding air quality standard. If the current air quality is far lower than the air quality standard, the extent and effects of the Operation on the environment must be explicitly explained.

7. Examination of Environmental Mitigation Measures

In case the predicted change of air quality due to the Operation is evaluated to give potentially significant impacts on the environment in the area, measures to prevent or mitigate the impacts must be examined, and their effects on the environment must be evaluated. Further predictions and evaluations may be required to have suitable mitigation measures.

8. Examination of Impacts of Alternatives

Impacts on environment of air quality changes by practicable alternatives to the Operation shall be evaluated and clarified. The major alternatives to the Operation and to the plant itself include:

- Power generation type
- Fuel kind
- Storage, handling and transportation of fuel
- Stack height
- Exhaust gas treatment
- Waste disposal
- Facility allocation

9. Formulation of Operation Monitoring Plan

(1) Contents of Monitoring

The Operation monitoring is aimed to confirm that the environmental impact assessment for the Operation has been appropriately conducted and that the plant is operating as planned. It consists of environmental monitoring and source monitoring. Air pollution is one of the major environmental impacts caused by the Operation. The monitoring program for the air pollution during the Operation includes the following articles.

A monitoring for air pollution in operation stage includes air quality monitoring and pollution source monitoring. The pollution source monitoring consists of facility observation and emission monitoring of the Operation.

(2) Air Quality Monitoring

1) Monitoring Items -- The monitoring items shall be the predicted and evaluated ones. The factors on the meteorological conditions, etc. which were used for prediction shall be monitored as well.
2) Monitoring Area -- The monitoring area shall be the predicted area having been shown in the environmental impact statement for the Operation (EIA Report).
3) Monitoring Method -- Each monitoring item shall be one surveyed previously by either field survey or collection of existing data.
    a) Monitoring Time -- The monitoring times shall be the predicted times in the EIA Report for each pollutant.
    b) Monitoring Period -- The monitoring period for each monitoring item is the one which can give an accurate understanding of the environmental air quality and a scientific and proper comparison of the monitored air quality with the predicted ones described in the EIA Report.
    c) Monitoring Point -- The monitoring points for each item shall be selected from the predicted points for the predicted item concerned so that they can give an adequate understanding of the influence of the Operation and the environmental air quality.
    d) Measuring Method
        a. Measuring methods for field surveys shall be either the methods used in the EIA, or methods which can give results equal or higher in quality than those by the methods in the EIA.
        b. If existing data are collected and analyzed, they shall not only be measured at the predicted times in the EIA Report, but also be obtained by the methods which are equal or more accurate than the methods for obtaining the data used for the prediction in the EIA.

(3) Pollution Source Monitoring

1) Facility Observation -- The observation items for the facilities are the states of the facilities related to the predicted and evaluated items in the EIA. The states of the facilities include the outside appearances and operation of the facilities and the states of the adopted environmental mitigation measures. The facility observation is aimed to clarify the relation between the states of the facilities and the environmental air quality.

   a) Observation Method -- On-the-spot survey is adopted.

   b) Time -- The observation times are the predicted times in the EIA. They shall be adjusted to the times of the air quality monitoring.

   c) Period -- The observation period shall be determined so as to know the states of the facilities properly.

   d) Method -- Such a method as actual measurement shall be taken in order to compare the results with the states of the facilities described in the plant design.

2) Emission Monitoring

   a) Monitoring Item -- Items to be monitored shall be the emissions (emitted pollutants, fuels, etc.) related to the predicted items, and the effectiveness of the environmental mitigation measures.

   b) Monitoring Method -- Field surveys shall be conducted for the emission monitoring, with the following remarks:

      a. Monitoring Time -- The monitoring times are the predicted ones. They shall be in harmony with the times for the air quality monitoring.

      b. Monitoring Period -- The monitoring periods shall be suitable to know accurately the state of the emissions.

      c. Measuring Method -- Follow the methods stipulated by the relevant laws, etc.

10. Execution of Operation Monitoring

(1) Operation Monitoring

Operation monitoring must be carried out according to the monitoring plan. If it is evident that areas other than the predicted area is affected by the Operation, they must be included in the monitoring area. In case changes in social conditions, etc. oblige a long delay of the planned operation assumed in the prediction, the monitoring shall be postponed until the time when the Operation becomes stable.

The monitored results have to be arranged as follows.

1) Air Quality

   a. Describe objectively and accurately the state of the environmental air quality in the area at each monitoring time.

   b. Compare the predicted and monitored results in tables and figures, for each item.

   c. Arrange predicted conditions and ones at monitoring in tables and figures, for the meteorological parameters important to the prediction and evaluation,

2) Facilities -- The results of the facility observation are so arranged in tables, etc. as to compare the actual location, scale, structure, operational characters, etc. of the facilities with their plans.

3) Emissions -- The results of the emission monitoring are so arranged in tables, etc. as to compare the actual states of the facility operation, emitted pollutants and environmental mitigation measures with their planned operations and designed values.

(2) Evaluation of Monitored Results

1) Air Quality -- The actual environmental states shall be realized in comparison with the predicted results. Those conditions which affect the environmental air quality other than the Operational ones (such as meteorological parameters) shall be carefully considered in evaluating the difference between the predicted air quality and monitored one.

2) Facilities and Emissions -- Check the actual location, kind, scale, structure, operation, etc. of the facilities, efficiencies of the control equipment, and the concentrations and amount of the emitted pollutants and compare the results with their planned and predicted ones.

3) Effects of Environmental Mitigation Measures -- The effects of the environmental mitigation measures are clarified and compared to their planned values.

(3) Strengthening of Environmental Mitigation Measures

If the monitoring results differ significantly from their predicted values in the EIA Report, their reasons shall be clarified. If the Operation is proved to give a significant effect on the environmental air quality, stricter environmental mitigation measures must be stated clearly.

Appendix 10-2

TECHNICAL GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT ON WATER POLLUTION BY THERMAL POWER PLANTS DURING OPERATION (FRAMEWORK)

1. Major Water Pollution by Thermal Power Plants during Operation

Generally speaking, wastewater due to a thermal power plant operation (Operation) which give impacts on rivers, lakes, ponds, the sea, bottom sediment and groundwater are roughly classified as follows, though they may be slightly different in nature depending on the fuels used.

a. Wastewater for cleaning of equipment and facilities
b. Wastewater containing chemicals (including cooling tower bleed)
c. Domestic wastewater

These three kinds of wastewater contain heavy metal ions, oil, acids, alkalis, organic compounds, which will give impacts on water environment. They shall be the targets of environmental impact assessment.

2. Data Collection

If the wastewater due to the Operation is planned to be discharged into surrounding water bodies, it is necessary to know current qualities, hydrology, etc. of the surrounding water bodies.

Items which will have environmental impacts of water pollution shall be selected accordingly to the qualities and volume of wastewater, the states of the surrounding water bodies, etc.

(1) Survey Item

1) Quality

(a) Surface water

a) Items on living environmental protection: pH, BOD, COD, DO, etc.

b) Items on people's health protection: Cd, As, Hg, Cyanides, etc.

c) Others: Water temperature, SS, N, P, etc.

(b) Bottom sediment

a) Sulfide, etc.

b) Items for people's health protection: Cd, As, Hg, Cyanides, etc.

(c) Groundwater

Items depending on the use of groundwater

2) Hydrology

(a) River

a. Flow rate, flow speed, self-purification coefficient, etc.

b. Features of river

(b) Lake and pond

a. Water level, holding capacity, inflow and outflow rates, water circulation, diffusion, etc.

b. Features of lake or pond

(c) Sea

a. Tidal level, current, permanent current, inflow rates of rivers, water circulation, diffusion, etc.

b. Features of seashore, etc.

(d) Groundwater

a. Water level

b. Stream direction, etc.

3) Meteorology -- Meteorological features affecting flow of rivers (temperature, wind direction, wind speed, precipitation, etc.), etc. shall be surveyed.

4) Water Use -- Use for drinking water, etc. and their future plan, etc.

5) Other Emission Sources (than the power plant) -- Sewage disposal plants, factories and establishments, etc.

6) Laws and Regulations -- Environmental standards on water bodies and emission standards of wastewater, etc.

(2) Survey Area

The survey area is the water areas on which the Operation may give water pollution. It is determined in consideration of the type and scale of the Operation, and the surrounding water environment.

(3) Survey Method

Existing data shall be collected, or if it is not enough, field survey shall be carried out.

1) Surface water -- Field surveys or the existing data is required for which period

gives a correct understanding of the water quality, etc. throughout a year. Frequency of the survey shall be, in principle, one day in every month. However, the seasonal variation of the water quality, etc. can simply be surveyed if the nature of the water area and the scale and type of the plant allow.

River qualities etc. shall be surveyed at time of low water flow and also for use of water. Survey times of lakes, ponds and the sea shall be determined in consideration of their stratification period and circulation period.

2) Bottom sediment -- When the bottom sediment is to be surveyed, it shall be when the current or flow is stable. Points near the wastewater discharges and points where sludge tends to pile up shall be selected for river sediment survey.

3) Groundwater -- Field surveys is required for a period during which the groundwater level is comparatively stable. It is acceptable to survey just the seasonal quality changes of the groundwater. The survey points shall be determined so as to give an adequate understanding of the changes due to the Operation.

4) Hydrology -- Hydrology can be surveyed together with the water quality. It shall be carried out for a year.

5) Meteorology -- Meteorology can also be observed when the water qualities are surveyed. It shall be carried out for a year.

3. Current Environment

The collected data shall be processed and analyzed to realize the current water environment of the water area. In the analysis, topography, flow, current, emission sources nearby, etc. shall be considered.

Summarized are such items as damages to human health, animals and plants due to water pollution, and their complaints.

4. Future Prediction

Changes in water quality, etc. shall be predicted at the time when the Operation becomes on stream at normal conditions.

(1) Prediction Item

The prediction items are water quality, etc. due to emissions by the Operation. They have to be predicted in terms of average value.

(2) Predicted Area -- The predicted area is the same as the survey area.

(3) Prediction Method

Emission rates can be determined from the design data or operational data of similar plants. For pollutant dispersion simulation, suitable prediction methods shall be selected depending on the type and scale of the power plant and the nature of the water area.

1) Numerical Simulation -- Dispersion of the wastewater can be simulated by a suitable model in consideration of the flow of the wastewater, flow of the water area, heat balance between the atmosphere and water surface, and factors affecting the flow and dispersion in the water area (condition and location of the discharge of the wastewater, conditions on topography, meteorology, hydrology, etc.).
2) Reference to Similar Experiences -- Experiences in similar plants of a scale, the topography, the discharge conditions, etc. can be used for prediction.

5. Impact Evaluation

(1) Evaluation Item -- Evaluation items are the same as the prediction items.

(2) Evaluation Method

Impact of the Operation on the environment (people, plants, animals, water use, aquatic resources, etc.) shall be evaluated in consideration of the regional characteristics, adopted environmental mitigation measures and indices of evaluations.

(3) Evaluation Indices

Indices for impact evaluation are shown below.

a. Environmental quality standards or targets
b. Emission standards
c. Other scientific knowledge on influences of water pollution on people's health, plants, animals, water use, aquatic resources, etc.

6. Examination of Environmental Mitigation Measures

In case the predicted changes of water quality, etc. due to the Operation is evaluated to give potentially significant impacts on the surrounding environment, measures to prevent or mitigate the impacts must be examined, and their effects on the environment must be evaluated. Predictions and evaluations shall be repeated to have suitable mitigation measures, as needed.

7. Examination of Impacts of Alternatives

Impacts on environment of changes in water quality, etc. by feasible alternatives for the plant shall be evaluated and clarified. The major alternatives to the Operation and to the plant itself include;

- Fuel kind
- Kind and consumption of chemicals
- Type and efficiency of wastewater treatment system

8. Formulation of Operation Monitoring Plan

(1) Operation Monitoring

Operation monitoring is aimed to confirm the environmental impact assessment for the Operation has been appropriately conducted and that the plant is operating as planned.

The Operation monitoring plan has to include environmental monitoring and pollution source monitoring in the operational stage. The former aims to confirm the change of water quality, etc. The latter aims to confirm the quality of the discharged wastewater.

(2) Environmental Monitoring

1) Monitoring Item -- The monitoring items are the same as the predicted and evaluated ones. The items on the parameters of hydrology which have been used for prediction shall be monitored as well.
2) Monitoring Area -- The monitoring area is the same as the survey area.
3) Monitoring Method -- Each monitoring item is surveyed by the same method as that used for data collection.
4) Monitoring Period -- The monitoring of each monitoring item are for which period can give an understanding of the environment and compare the monitored water quality, etc. with the current and predicted ones.

(3) Pollution Source Monitoring

1) Monitoring Item -- The pollution source monitoring aims to know the pollutant

emissions, etc. related to the predicted and evaluated items, and the effects of their environmental mitigation measures.

2) Monitoring Method -- The same method applied in the data collection is used for each predicted and evaluated item.

3) Monitoring Period -- The monitoring periods shall be suitable to know accurately the states of the effluents, etc.

9. Execution of Operation Monitoring

Operation monitoring must be carried out according to its monitoring program. If areas other than the predicted area is apparently affected by the Operation, they must be included in the monitoring area. The monitored results shall be so arranged as to be able to compare the actual states with the predicted results, predicted conditions and planned values.

10. Strengthening of Environmental Mitigation Measures

In case the monitoring results differ significantly from their predicted values, their relation to the Operation must be clarified. If the Operation is proved to give a significant impact on the water environment, stricter environmental mitigation measures must be clearly stated.

Appendix 10-3

REMARKS ON ENVIRONMENTAL IMPACT ASSESSMENT

[I] Remarks on EIA

1. Survey, Prediction and Evaluation

(1) Objectivity of Methods

In order to assure quality of studies on environmental impact assessment (EIA), methods for survey, prediction and evaluation shall be as objective as possible. They are preferably equal to methods or based on similar methods to ones admitted or used by scientific societies, administrative agencies or research institutes in the past.

(2) Reliability of Data

It is desirable that existing data used for survey, prediction and evaluation are the latest ones. Not desirable are such data surveyed under unusual conditions like abnormal meteorological condition or at points which does not represent the situation of the area. Therefore, contents and survey conditions of the data shall be checked beforehand to judge their reliability.

(3) Quantitative Approach

In order to clarify impacts of the Operation, survey, prediction and evaluation shall be as quantitative as possible. If the quantitative approach is difficult due to the premature Operation plan or lack of adequate methods for the approach, a qualitative approach is acceptable with reasons why the quantitative approach is difficult.

2. Preparation of EIA Report

(1) Description

Description of EIA Report (EIS) shall be consistent in each section as a whole.

(2) Expression

The EIS shall be described in simple and easy expression as much as possible. Visual expressions are easy to understand.

(3) Terminology

Difficult terms, peculiar terms or carelessly coined words shall not be used. Technical jargons shall be avoided as much as possible.

(4) Grounds

Grounds and reasons shall be clarified for the following matters;

a. Selection of prediction and evaluation items
b. Selection of survey items
c. Determination of survey area
d. Determination of survey points
e. Selection of survey methods
f. Prediction condition
g. Factors and values used for prediction
h. Evaluation indices
i. Environmental mitigation measures
j. Alternatives
k. Other

(4) Field Survey

When field surveys are carried out , following matters shall be described;

a. Survey point or survey area
b. Survey date or survey period
c. Surveyor (name and address of entrusted person)
d. Survey method
e. Name of survey equipment
f. Weather
g. Other

(5) Prediction

In case a part or whole of the prediction is entrusted, describe the name and address of the entrusted person.

(6) Data

A large amount of technical or professional data shall be compiled into a separate data book of such a style as people can easily refer to and make comments for environmental mitigation.

[II] REMARKS ON OPERATION MONITORING

1. Preparation of Operation Monitoring Plan

(1) Description of Monitoring

Operation monitoring is aimed to clarify appropriateness of the EIA for the Operation. Operation monitoring plan has to describe concretely the monitoring (time, period, point, method for each predicted item) for each predicted and evaluated item in the EIA.

(2) Pollution Source Monitoring

Both environmental monitoring and pollution source monitoring shall be conducted for each predicted and evaluated item in the EIA. However, depending on the reality of the predicted and evaluated items or of the environmental mitigation measures, the Operation monitoring will not be needed. If it is the case, its reasons shall be clearly described.

2. Execution of Operation Monitoring

(1) Objectiveness

Operation monitoring, like prediction and evaluation in the EIA, shall be conducted objectively and scientifically. Operation monitoring shall be equal or superior in accuracy and preciseness to the ones carried out for prediction and evaluation. The monitored results shall be compared with those of the prediction.

(2) Quantitativeness

Operation monitoring shall be as quantitative as possible.

3. Preparation of Operation Monitoring Report

(1) Arrangement of Monitoring Results

Results of Operation monitoring are arranged for each monitoring item so as to have a comparison with actual previous survey results and predicted values described in EIS. Similarly arranged are such matters as meteorology and water sphere which will give influences on Operation monitoring results.

(2) Description

Technical terms shall be used to a minimum in a Operation monitoring report. It shall be written in as simple and easy expression as possible. Visual expressions like figures and tables are recommendable for easy understanding.

(3) Identification of Data and Survey

Source, name, date, etc. of existing data used for environmental monitoring, and measurement or survey method, date, surveyor, etc. of field surveys shall be identified.

(4) Data

A large amount of technical and professional data shall be arranged in a separate data book.

Appendix 10-4

ENVIRONMENTAL IMPACT SOURCES AND THEIR POTENTIAL IMPACTS OF STEAM POWER PLANTS

Note: This appendix is composed from mainly U.S.EPA publication (#68) and others. Coal fired plants are included here for the future in Iran.

1. Significant Environmental Problems

1.1 Location

Because steam power plants are large installations, and because a suitable water supply is needed, new plants usually will be built in rural areas. The construction and operation of power plants in rural locations usually involves significant changes in land use, which may be accompanied by direct social and sociological impacts. Secondary, or indirect impacts, such as induced growth, infrastructural changes, and demographic changes also may occur; however, they would be associated primarily with the construction phase, because that is when the labor force is highest. The significance of such impacts depends largely on the local economy, existing infrastructure, characteristics of construction workers (e.g., local or non-local). Long term secondary impacts usually are not so significant, because the operational phase is non-labor-intensive.

1.2 Fuels and Raw materials

The major environmental problems associated with fuels and raw materials are from handling, transport, and storage of the coal where it is used for fuel; also lime/limestone where flue gas desulfurization is employed. Runoff from on-site storage piles can cause significant environmental problems, as can the construction of transportation facilities needed to bring these solid materials to the site and their actual transportation. Environmental problems with oil and gas fuels arise primarily from leaks, spills or ruptures during transport to the power station.

1.3 Process

Power plant processes can have a number of associated environmental impacts. These include:

(1) Stacks, boilers: The height and size of the stacks, boilers, and other equipment generally will have an aesthetic impact.

(2) Coal processing: Runoff and process waters can be contaminated to the point of causing ecological damage if not properly treated before discharge.

(3) Heat dissipation: Large amount of heat must be dissipated and various impacts can occur depending on the type of dissipation system selected:

- Once-through cooling can result in ecological impacts because of impingement and entrainment of aquatic organisms at the intake structure and excessive increases in ambient water temperatures in the discharge area.

- Cooling towers greatly reduce the impingement, entrainment, and heat problems, but can cause unfavorable aesthetic impacts because of their large size and visible plumes. Other environmental problems can result from fogging, icing, or salt deposition and from the discharge of blow-down containing large quantities of dissolved and suspended solids, and chemicals if added.
- Cooling lakes may require the conversion of substantial terrestrial acreage to an aquatic ecosystem, and may involve changing a segment of a free-flowing stream to a permanent lake environment. Proper design of the lake is needed to ensure that dissolved solids do not develop high concentration and eutrophication problems do not occur.

(4) Transmission and railroad lines: Construction and maintenance of transmission and railroad lines involve environmental disturbance over long, narrow areas, with possible aesthetic and ecological disturbances. Railroad lines can involve extensive changes in runoff patterns. Maintenance of transmission and railroad lines involves herbicides or other methods of weed and brush control.

(5) Fuel combustion: Coal-fired plants and, to a lessor extent, those using oil (excepting SO_2 emission from fuel oil) produce environmentally damaging air emissions which may be visually displeasing due to opacity, and may also contain SO_2, particulate, nitrogen oxides, and possibly radio-active trace metals and fluorides, if proper control technology is not used. Also, the combustion of coal results in the production of large quantities of solid wastes in the form of ashes and possibly sludge from SO_2 scrubber. The area required to store these wastes may involve a land use change and the leachate from such storage areas can contaminate ground or surface waters by the presence of heavy metals, acids, bases, etc..

(6) Chemical cleaning, demineralization: Wastes from chemical cleaning of equipment and from the demineralization process used to prepare make-up water could cause ecological damage in the receiving water if not properly treated before discharge. Such wastes also are associated with pre-operational cleaning and treatment of metal surfaces, usually a large one-time discharge.

(7) Hazardous material storage and handling: Materials often present in power plants include fuel, transformer oils, strong acids and bases, and solvents. Accidents may result in discharge of these hazardous materials unless proper spill containment measures are taken.

1.4 Pollution Control

Although pollution control processes will reduce adverse impacts that result from various waste streams, the same processes can create other kinds of adverse impacts. For example, the heat dissipation process probably has the highest potential for adverse impact. This process can lead to a variety of potential environmental impacts from cooling towers, cooling lakes, cooling ponds, or once-through cooling systems (see Section 1.3).

Air pollution control processes also generate liquid and solid wastes in the form of the residue from scrubbing operations and particulate removal. Another pollution control process that can lead to adverse impacts is the evaporation pond, often used in arid areas to dispose of cleaning and demineralization wastes, cooling tower blowdown, laboratory wastes, etc.. Groundwater contamination is possible unless the pond is impermeable and, therefore, suitable provisions are needed to cover the pond when it is no longer functional to prevent leaching or washing out of contaminants. Also during the reuse and recycling of plant water, certain elements may become concentrated which could result in contamination of ground and surface waters.

2. Impact Identification

There are two different kind of environmental impacts; impacts for construction (site preparation and facility construction) phase and for operation phase.

2.1 Construction Phase

(1) Construction works

The environmental effects of preparation of the site and construction of the new power plant normally are not unique to the electrical generating industry. Any major land-disturbing construction project probably will have similar impacts. Main potential environmental impacts include noise and vibration from operation of construction equipment, and terrestrial impacts such as damage to vegetation, decline of wildlife, reduction of agricultural resources, and impairment to conservation of natural areas.

Table 1 shows a checklist of important study items. The basic components of site preparation and plant construction include pre-construction, site work, permanent facilities, and project closeout. Whereas only potentially significant areas of impact are presented in this checklist, a system of values and significance shall be assigned to the checklist items after sufficient quantitative data have been acquired for an individual site or for a region. All proposed control practices shall be tailored to the specific site(s) being considered in order to account for and to protect special features of the site (e.g., critical habitats of important or imperiled species, archaeological /historical sites, high quality streams, wetlands or other sensitive areas on the site). All mitigating measures which are proposed to avoid or reduce adverse impacts from site preparation and construction activities shall be described in the EIA.

Construction activities for steam power plants may include the followings:

1. Clearing of the ground for use as laydown areas.
2. Erection of a temporary-concrete batch plant.

3. Development of access roads and employee parking lots.
4. Constructions of railroad spurs.
5. Excavation for major plant structures.
6. Cooling tower erection.
7. Construction of the plant up to grade.
8. Erection of turbine pedestal.
9. Setting down cofferdams.
10. Construction of intake and discharge lines and structures.
11. Dredging operations.
12. Trenching for laying pipe for fuels and service water.
13. Back-filling.
14. Installation of storm sewer lines and holding basins.
15. Construction of water front facilities.
16. Construction of fuel storage facilities.
17. Preparation of solid waste disposal area.
18. Erection of retention dams.
19. Cooling lake and ponds.
20. Aggregate development and production.

Those construction activities estimated to result in significant environmental effects and impacts shall be identified and described, and scheduled start and completion dates for these shall be tabulated in order to estimate the duration of effects and impacts. A list of manpower requirements, on a yearly basis, for site preparation and plant construction shall be presented.

The applicant should delineate in general terms the methods being proposed for excavation, dredging, back-filling and dewatering operations, and discuss other techniques to be used during construction, if any are anticipated. Special mention shall be made of any proposed use of explosives, and of heavy equipment for clearing and excavating, and transporting materials to and from the site. A schedule of these activities would be useful in determining impacts.

Describe briefly the nearest rail-heads, their distance away and the intervening road system.

An estimate of the quantities of solid waste to be disposed of shall be provided. The source, nature and quantity of any fill material to be used during construction shall be specified. Provide the source of fresh water for construction.

Discuss delivery of the heavy equipment to the site. A schedule of these activities would be useful.

(2) Transportation

A large number of trucks are required in construction phase. They are used to transport construction equipment and machinery, construction materials, and construction wastes such as surplus soil. They emit air pollutants, raise a cloud of soil dust, and cause noise and vibration. Therefore, their potential impact on Air quality, noise, and vibration shall be evaluated.

Table 1 Outline of Potential Environmental Impacts and Relevant Pollutants Resulting From Site Preparation and Construction Practices (#68, 70)

Construction Practice	Potential Environmental Impacts	Primary Pollutants
1. Pre-construction		
a. Site inventory	Short term and nominal	Dust, noise, sediment
(1) Vehicular traffic	Dust, sediment, tree injury	
(2) Test pits	Tree root injury, sediment	
b. Environmental monitoring	Negligible if properly done	Visual
c. Temporary controls	Short term and nominal	Sediment spoil, nutrients, solid waste
(1) Sedimentation ponds	Vegetation destroyed, water quality improved	
(2) Dikes and berms	Vegetation destroyed, water quality improved	
(3) Vegetation	Fertilizers in excess	
(4) Dust control	Negligible if properly done	
2. Site work	Short term	
a. Clearing and demolition		Dust, sediment, noise, and vibration
(1) Clearing	Decrease area of protective tree, shrub, ground covers, stripping of topsoil; increased soil erosion, sedimentation, stormwater runoff; increased stream water temperatures; modification of stream banks and channels, water quality	
(2) Demolition	Increased dust, noise, vibration, solid wastes	

Table 1 Outline of Potential Environmental Impacts and Relevant Pollutants Resulting From Site Preparation and Construction Practices -- Continued

Construction Practice	Potential Environmental Impacts	Primary Pollutants
b. Temporary facilities	Long term	Gases, odors, fumes, particulates, dust, deicing chemicals, noise, vibration, petroleum products, waste water, solid wastes, aerosols, pesticides
(1) Shops and storage sheds	Increased surface areas impervious to water infiltration, increased water run-off, petroleum products	
(2) Access roads and parking lots	Increased surface areas impervious to water infiltration, increased water run-off, generation of dust on unpaved areas	
(3) Utility trenches and backfills	Increased visual impacts, soil erosion, sedimentation for short periods	
(4) Sanitary facilities	Increased visual impacts, solid wastes	
(5) Fences	Barriers to animal migration	
(6) Laydown areas	Visual impacts, increased runoff	
(7) Concrete batch plant	Increased visual impacts; disposal of wastewater, increased dust, noise and vibration	
(8) Temporary and permanent pest control (termites, weeds, insects)	Nondegradable or slowly degradable pesticides are accumulated by plants and animals, then passed up the food chain to man. Degradable pesticides having short biological half-lives are preferred for use	
c. Earthwork (1) Excavation (2) Grading (3) Trenching (4) Soil treatment	Long term Stripping, soil stockpiling, and site grading; increased erosion, sedimentation, and runoff; soil compaction; increase in-soil levels of potentially hazardous materials; side effects on living plants and animals, and the incorporation of decomposition products into food chains, water quality	Dust, noise, vibration, sediment, debris, wood wastes, solid wastes, pesticides, particulates, bituminous products, soil conditioner chemicals

Table 1 Outline of Potential Environmental Impacts and Relevant Pollutants Resulting From Site Preparation and Construction Practices -- Continued

Construction Practice	Potential Environmental Impacts	Primary Pollutants
d. Site drainage	Long term	Sediment
(1) Foundation drainage (2) Dewatering (3) Well points (4) Stream channel relocation	Decrease volume of underground water for short and long time periods, increased stream flow volumes and velocities, downstream damages, water quality, habitat alteration	
e. Landscaping	Long term	Nutrients, pesticides
(1) Temporary seeding (2) Permanent seeding and sodding	Decreased soil erosion and overland flow of stormwater, stabilization of exposed cut and fill slopes, increased water infiltration and underground storage of water, minimize visual impacts	
3. Permanent facilities		Sediment, dust, noise, particulates
a. Transmission lines and heavy traffic areas	Long term	
(1) parking lots	Stormwater runoff, petroleum products	
(2) Switchyard	Visual impacts, sediment, runoff	
(3) Railroad spur line	Stormwater runoff	
b. Buildings	Long term	Solid wastes
(1) Warehouses	Impervious surfaces, stormwater runoff, solids wastes, spillages	
(2) Sanitary waste treatment	Odors, discharges, bacteria, viruses	
(3) Cooling towers	Visual impacts	
c. Related facilities	Long term	Sediment, trace elements, noise, vibration, caustic chemical wastes, spoil, flocculants, particulates, fumes, solid wastes, nutrients
(1) Intake and discharge channel	Shoreline changes, bottom topography changes, fish migration, benthic fauna changes	
(2) Water supply and treatment	Waste discharges, water quality	

Table 1 Outline of Potential Environmental Impacts and Relevant Pollutants Resulting From Site Preparation and Construction Practices -- Continued

Construction Practice	Potential Environmental Impacts	Primary Pollutants
(3) Stormwater Drainage	Sediment, water quality	
(4) Wastewater treatment	Sediment, water quality, trace elements	
(5) Dams and impoundments	Dredging, shoreline erosion	
(6) Breakwaters, jetties, etc.	Circulation patterns in the water way	
(7) Fuel handling equipment	Spillages, fire, and visual impacts	
(8) Oil storage tanks, controls, and piping	Visual impacts	
(9) Conveying systems (cranes, hoists, chutes)	Visual impacts	
(10) Cooling lakes	Conversion of terrestrial and free flowing stream environment to a lake environment (land use tradeoffs); hydrological changes, habitat changes, sedimentation, water quality	
(11) Solid waste handling equipment (incinerators, wood chippers, trash compactors)	Noise, visual impacts	Particulates, dust, solid wastes
d. Security fencing	Long term	Sediments, wood wastes
(1) Access road	Increased runoff	
(2) Fencing	Barriers to animal movements	
4. Project closeout		
a. Removal of temporary offices and shops	Short term	Noise, dust, solid wastes
(1) Demolition	Noise, solid waste, dust	
(2) Relocation	Stormwater runoff, traffic blockages, soil compaction	

Table 1 Outline of Potential Environmental Impacts and Relevant Pollutants Resulting From Site Preparation and Construction Practices -- Continued

Construction Practice	Potential Environmental Impacts	Primary Pollutants
b. Site restoration	Short term	Sediment, dust
(1) Finish grading	Sediment, dust, soil compaction	
(2) Top soiling	Erosion, sediment	
(3) Fertilizing	Nutrient runoff, water quality	
(4) Sediment controls	Vegetation, water quality improved	
c. Preliminary start-up	Short term	Nutrients, petroleum products
(1) Cleaning	Water quality, oils, phosphate and	
(2) Flushing	other nutrients	

Source: (#68) Environmental Impact Assessment Guidelines for New Source Fossil Fueled Steam Electric Generating Stations EPA-130/6-79-001

(#70) Power Plant Siting, J.V. Winter et. al.

2.2 Operation Phase

2.2.1 Fuel Handling and Storage

(1) Coal

The potential environmental impacts associated with coal handling and storage primarily result from coal storage area runoff and particularly from generation of dust. Dust generation from coal handling arises mainly at unloaders, coal falling places at conveyer shoots, and conveyers. The control measures include installation of water spray units, making the conveyers airtight. By these measures generation of dust is almost prevented. A power plant must store coal to maintain a continuous supply to the burners between shipments. The live storage pile generally contains sufficient coal to maintain the supply between scheduled coal shipments; in addition, a permanent storage pile is maintained as a cushion against interruptions in the delivery schedule.

Coal contains various elements that may enter thin films of water found when the coal is damp and exposed to air. Rainfall will wash off this thin film, producing an initial runoff that is often acid and usually high in concentration of iron, copper, and/or zinc, and that has objectionable amounts of suspended solids and organic material. The acid and reducing nature of the runoff is caused by the sulfur compounds in the coal; these characteristics increase the solubility of many metallic impurities.

(a) Terrestrial Impacts

a) Dust from coal storage

In general, dust generation from coal does not occur if the free moisture of the coal is more than 7%. Dust generation from coal storage piles is more likely to occur in case the free moisture of the pile surface is low and strong wind blows. The wind speed blowing up along the coal storage piles usually reaches about twice as high as that on the ground, which generates collapse of the coal at the pile top. The collapsed gobs of the coal fall down the slope and destroy the pile surface, accelerating dust generation.

There are following three measures to suppress dust at active storage piles;

- Occasional water sprays
- Installation of a windbreak net around the coal storage piles
- Installation of dust collectors

b) Runoff and infiltration water

Runoff and infiltration water from the storage piles can remove some of the more soluble materials from the coal and introduce them into surface water, soil, and ultimately groundwater. Water-soluble material from the storage pile arises mainly from oxidation of the coal surface during exposure to the air and rainfall in unconfined coal piles. Runoff and infiltration water from these piles likely contain coal fines, humic acids, sulfuric acid, and inorganic ions. The concentrations of the constituents of water after contact with the piles depend on the:

- Type of coal
- Extent of exposure to local climatic conditions
- Acidity of the rainfall
- Temperatures within the pile
- Length of contact time between the water and the coal

The terrestrial effects of this water are likely to be qualitatively similar to effects of acid coal mine drainage, but the volumes and concentrations normally are small compared to those of mine drainage. Effects on the land shall be considered for areas immediately below, and adjacent to, the piles. Organic matter and cations in the soils at these locations could be subject to leaching by the acid waters and could be depleted from the surface horizons.

(b) Aquatic impacts

Runoff water from coal storage piles is a potential source of surface and groundwater contamination. Experience with gob and slurry piles associated with coal cleaning plants indicate some of the problems may arise. Gob and slurry piles may have a high coal content and runoff water often has a low pH and contains suspended coal fines and high concentrations of iron, sulfates, and many trace elements. Groundwater also may be of poor quality in the vicinity of these piles.

These same problems may occur runoff from coal storage piles, although to a lesser extent. Good coal pile management techniques limit contact of water with coal, and many contaminants in coal suitable for use in electrical power generation are present in much lower concentration than in coal processing wastes.

In case coal is left in the air for a long time, coal is oxidized and reduces its heating value. This phenomenon is named weathering. The heat accumulated in a coal pile accelerates further weathering, which causes spontaneous ignition of the coal. Coal with higher volatile matter, or smaller grading coal due to increase of surface area are more likely to be subject to oxidation. Water infiltration into coal storage piles increases the danger of spontaneous ignition of this coal and reduces its heating value, good coal pile management should include such techniques as:

- Laying the pile on a dry and relatively impervious foundation
- Sealing the pile surface by compacting or other means in order to

minimize coal-water contact.

The applicant should take measures to minimize the chance of runoff reaching surface water, and to limit or prevent infiltration of water into soils.

Coal fines transported into aquatic systems could produce substrate alterations capable of altering or eliminating the benthic community and impacting the fish community through loss of food supplies and loss of spawning habitat. The effect of dissolved materials in such runoff upon the aquatic community shall be estimated and discussed in the EIA.

The significance of the impacts resulting from such waste streams on the terrestrial and aquatic resources in the study area will depend largely on site-specific factors. Thus the applicant should identify all related factors in order to accurately assess impacts and to design and implement adequate mitigation measures.

(2) Oil and Gas

Oil and gas may be brought to the plant by means of tankers, barges or pipelines. Potential environmental impacts from handling these fuels derive from spills and leaks, and generally the severity of impacts is proportionate to the quantity of the spill or leak, as well as the sensitivity of the site. Because the supply function is large and complex, it is inevitable that accidents will occur, although theoretically they are avoidable. These potential impacts shall be discussed statistically, based on statistical frequencies of accidents that have occurred in similar operations.

2.2.2 Process and Associated Waste Streams

The generation of electricity in a fossil-fueled plant involves several processes which generate a variety of waste streams. The treatment of these streams and their final impact on the environment must be in the environmental impact assessment (EIA). The characteristics of the individual waste streams are discussed below.

The applicant should identify specific pollutants and explain, in the EIA, the proposed method(s) for treatment and disposal of all wastes and the associated potential impacts.

(1) Continuous Aquaous Waste Streams

(a) Heat dissipation systems

One of the basic characteristics of a steam power plant is that about 1.5 to 2 times more energy must be dissipated as heat than is actually generated as electricity, due to thermodynamic limitations on the process of converting heat to electrical energy. There are four basic means by which heat is transferred from water to air: conduction or convection, evaporation, radiation, and advection. There are basically three alternatives for heat dissipation system: (1) once-through cooling, (2) cooling towers, (3) cooling lakes, ponds , and canals.

a) Once-through cooling

Once-through cooling systems utilize the natural ability of the receiving water body to dissipate the heat by these natural processes. A once-through system describes an arrangement which draws water from a natural water body, utilizes the water throughout the condenser system, and then discharges the water back into the original source. Thus, the water passes through the system once and then is discharged. It requires a large body of water to achieve proper heat dissipation.

A once-through cooling system is simple, efficient, and economical, but it does have problems resulting from withdrawal, treatment, and discharge of water: the heated water which is returned to the river, lake, or ocean can cause biological damage and disrupt the existing ecosystem in the receiving water body. Potential impacts include:

1) Effects on important local biota

The effects of the heated plume must be evaluated for phytoplankton, periphyton, aquatic macrophytes, zooplankton, macroinvertebrates, shellfish, larval fish, and adult fish to the extent that these various types of biota are important to the ecology of the receiving water.

Because of the great complexity and variety of the aquatic ecosystems, the effect of heated effluents from a once-through cooling system or a cooling pond usually must be considered by evaluating the effect on biota at various trophic levels.

- Mortality

  Where applicable the applicant should discuss the potential for direct mortalities of fish and benthic communities within the effluent zone from thermal stress (cold and heat shock) based on known thermal tolerances.

- Growth

  The applicant should address the potential for inhibiting effects on growth and maturation at the species and community level.

- Reproduction

  Where applicable, the applicant should assess potential adverse effects on spawning site, reproductive potential, and nursery grounds, to ensure the protection and propagation of a balanced aquatic community.

- Avoidance

  The diversity and relative abundance of the normally occurring mobile aquatic biota may be affected within the mixing zone because of avoidance of the thermal plume. In cold climates the heated water may serve as an attraction to some organisms. These effects shall be assessed, as the possible interference with migrations (especially in riverine and estuarine environments.)

- Physical/Chemical and Water Quality

  The applicant should discuss in site-specific terms, those water quality factors for which the impact on biota may be affected by temperature. For example, increased temperature results in an increase in the rate of biological oxygen consumption in the water and may result in a substantial decrease in dissolved oxygen locally (oxygen sag) ; decreased gas solubility at higher temperatures can result in local supersaturation and the damaging release of theses gases from solution; such compounds as ammonia may be more toxic to biota as the temperature increases.

2) Effects on Other Water

The effect of the heated effluent on recreation, public water supplies, industrial water uses, and other existing or proposed cooling water systems also shall be discussed in the EIA.

b) Cooling lakes

Similar biological impact mentioned above for once-through cooling shall be examined if cooling lakes are selected as a receiving body for thermal effluents.

c) Re-circulating cooling towers, ponds, and canals

Where natural lakes are not available and river flows are inadequate, man-made cooling ponds or canals can be constructed. Although the direct thermal effects from these cooling systems normally are less than from other available cooling modes, the blowdown and the water intake can have pronounced effects on small or confined water bodies. If large generating units are proposed and small water bodies will be used for makeup and blowdown, the applicant should assess the significance of potential impacts and develop appropriate measures to minimize any adverse impacts.

d) Cooling Water Intake Structures

All of the above cooling water systems usually will involve withdrawal of water from its local body to be used as direct cooling water or as makeup water. The applicant should assess all potential impacts associated with a proposed intake structure. The applicant must select proper siting and design of the intake and minimize impingement and entrainment of aquatic biota.

e) Biocide Use

The applicant should provide information sufficient to define the potential impact of the biocide(s) used (if any) on entrained organisms at their point of exposure, as well as any impacts expected beyond the point of discharge.

Currently chlorine is the most commonly used biocide in steam electric generating stations. The toxicity of intermittently discharged combined residual appears to be significantly less than that of the free residual chlorine.

(b) Water treatment system

Modern high pressure boilers require high quality water for makeup and frequently the available water supply must be treated before it can be used for general plant purposes. They may include:

1) Clarification
2) Softening
3) Demineralization

(c) Boiler blowdown

Blowdown is practiced to prevent the buildup of materials in the boiler. In modern high-pressure systems, blowdown water normally is of good quality; often it is returned to the water treatment system, because it usually will be of better quality than the water supply.

(d) Ash-handling water

Coal-fired plants produce both a finely divided ash that is removed from the stack gases by electrostatic precipitators and an ash that is removed from the bottom of the boilers. Ash usually is disposed of as solid waste, although some fly ash is used for cement manufacture and other industrial processes. Ashes may be transported dry or as a slurry in water. Dry ash transport must have adequate dust control; wet ash transport results in a wastewater containing materials dissolved from the ash. Dissolved materials also can be a problem in leachate from ash disposal sites. Coal ashes can contain significant quantities of Al, Fe, Si, Ca, Mg, Na, K, P, B, Ti, and trace metals including Hg, As, Se, Cd, Cu, Ni, V, and Zn. Water that has been in contact with ash may be alkaline or acid and may contain objectionable quantities of some of the foregoing materials; it may, therefore, have a detrimental effect on a receiving body of water. Oil-fired boilers produce much less ash; removal is usually by periodic washing.

(e) Stack gas scrubber system

Sulfur dioxide in stack gases is most commonly removed by bringing the stack gases into contact with an limestone slurry, which precipitates a mixed calcium sulfate sulfite that then can be disposed of as a solid waste. The water is recirculated, although there may be some blowdown.

(f) Miscellaneous waste streams

There are other waste streams that are not related specifically to the electric power generation process, but still must be evaluated in EIA. They include sanitary wastes, plant and yard drains, coal pile runoff, and laboratory wastes. Such wastes could result in potentially significant impacts to water quality. The applicant should also discuss in the EIA the method(s) proposed to manage such waste streams.

(g) Intermittent aqueous waste streams

Periodic cleaning of power plant equipment, such as boiler tubes, fire-side areas, stacks, cooling towers, condensers, and pre-operational metal cleaning produces wastes that may contain a wide variety of contaminants in quantities sufficient to cause environmental impacts. The composition of these wastes shall be identified as well as any potential impacts that are associated with these wastes. At least the following chemical constituents shall be investigated: acid, alkaline, detergent, and/or chelating compounds from cleaning solution, Fe, Cu, Zn, Ni, Cr, P, F, and organic materials.

2.2.3 Air emission waste streams

(1) Source of Emissions

Potential sources of air contaminants for fossil-fueled steam power plants include:

- Processing plants for fuel and other raw materials
- Materials loading, transport, unloading, and storage facilities
- Combustion equipment (usually the largest source of emissions)
- Fly ash and other waste disposal operation
- Cooling tower drift and salt deposition
- Indirect sources such as increased vehicular traffic generated by use of recreation areas (e.g., cooling lakes) or new residential housing to accommodate plant employees.

Emissions from such sources shall be evaluated on source and control equipment design, operating and maintenance factors, and analysis of fuel type. Significant emissions of all criteria pollutants and other hazardous substances must be qualified. Additional information on particulate emissions may be obtained based on consideration of aerosol mechanics. Particulate and gaseous behavior must be considered for some emissions; for example, many trace elements such as Sb, As, fluorine (F), Pb, Hg, Se, tin (Sn), and Zn are volatilized to varying degrees during combustion, are recondensed as the flue gas cools, and are released both as gases and as submicron condensation particulate that preferentially penetrate through air pollution control devices, whereas the unvolatilized forms are collected efficiently with the fly ash.

The emission of heat and moisture from the designed cooling system shall be evaluated. Emissions from auxiliary turbine or diesel generators and their operating schedules also shall be evaluated.

(2) Atmospheric Chemistry

Primary air pollutants emitted from these sources include SO_2, SO_3, NO, NO_2, particulate, hydrocarbons, CO, CO_2. However, after these various contaminants have been emitted to the atmosphere, a number of chemical reactions may take place under certain atmospheric and environmental conditions. Because many of the products of these reactions are potentially harmful to human health and welfare, the probability of their formation and the extent of impact expected must be evaluated.

SO_2, emitted as a product of the combustion of sulfur-bearing fossil fuels, can be oxidized to sulfate ($SO4^{-2}$) in a number of ways, both directly and catalytically. This oxidation is favored by the presence of moisture, sunlight, certain metals, hydrocarbons, oxides of nitrogen, and ozone.

Where SO_2 is oxidized to sulfate particles, contact with moisture, whether in the atmosphere or in the lungs, can lead to formation of sulfuric acid and sulfate salts. Through the same combustion process, the emission of NOx often leads to the formation of nitrates. The incorporation of sulfates and nitrates into cloud systems can result in acidic aerosols, mist, and acid rainfall on a regional scale.

Acid rainfall may adversely affect freshwater organisms by reducing pH (increasing acidity) of their environment.

Acid conditions may result in the leaching of minerals from soil and also may damage various materials, especially metals. Acute and chronic injury also may occur to vegetation, crops, and to the natural ecosystems (up to hundreds of kilometers downwind) as a result of SO_2 emissions which, in turn, can result in transient reductions of live plant biomass. If the fumigations are intermittent, the plant can recover by increased growth and replacement of damaged tissue. However, if the amount of damaged tissue exceeds a certain rate (depending on species), productivity or yield may be decreased.

Subtle long term effects also are possible, in which the SO_2 interferes with physiological or biological processes resulting in effects on growth and possibly on yield without visible symptoms.

Plant species and varieties show a considerable range of sensitivity to SO_2. This is the result of interactions of environmental (temperature, humidity, light, edaphic factors, etc.), phenological, morphological, and genetic factors that influence plant response.

In addition to acute SO_2 effects, which can result in visible injury to plants wherever they grow, the chronic and long-term SO_2 effects take on added significance in natural ecosystems because of the relative permanence of the vegetation and the delicate balances that exist between ecosystem components. As a contrast, in areas supporting managed agricultural ecosystems where the existing forage or crop plants are replaced by new plants each growing season, the chronic and long-term effects of SO_2 may be negligible.

It is likely that in natural ecosystems subjected to persistent SO_2 levels, annual and perennial plant species would be affected differentially. Chronic and /or long-term SO_2 effects may be manifested as impairment of reproduction and germination which could result in long-term changes in diversity (through elimination of sensitive species), community structure, productivity, stability, nutrient cycling, etc. These changes would, in turn, affect the animal components of the ecosystem via changes in habitat, food availability, competition, etc.. These effects would be in addition to the direct effects of SO_2 on animal species and shall be evaluated in the EIA to the extent practicable.

Air contaminants formed through atmospheric photo-chemistry are known as photo-chemical oxidants because of their roles as harmful oxidizing agents. They are produced through a complex series of atmospheric reactions mainly involving hydrocarbons, oxides of nitrogen, and moisture in the presence of sunlight. Oxidants, which include ozone, also are involved in some of the reactions that produce acid aerosols.

It is desirable to estimate potential impacts on people. At the minimum, it will be desirable to provide tabular data as to the number of people living within the isopleths delineating various levels of increased air contamination.

It is important when assessing the effects of air contaminants on people and environment that air quality standards are set at a value that will protect the public health and welfare. Therefore, these standards can form the basis for discussions concerning environmental impacts of air pollutants.

(3) Global Warming

The greenhouse gases in the atmosphere (CO_2, CH_4, N_2O, etc.) intercept radiation emitted from surface of the earth, and through this process the earth has been kept at certain level of temperature.

Global warming is the change in climate, which provides basis for mankind and ecosystem, due to the enhanced greenhouse effect by man-induced increase of CO_2 and other greenhouse gases which will cause the temperature of the Earth's surface to increase. Predicted global warming has never been observed over the last 10,000 years, the rate of which is characteristically higher in geological term.

According to the report of the Intergovernmental Panel on Climate Change (IPCC), it is projected under the business-as-usual scenario that the global temperature would rise by about 1℃ by 2025 and about 3℃ by the end of the 21st century above the present value, and that global mean sea level would rise by about 20 cm by 2030 and by 65 cm (with a maximum rise of 1 meter) by the end of the 21st century.

Power plants use large amounts of fuels and discharge large amounts of carbon dioxide. Global warming is now an urgent global environmental issue and control of CO_2 emission is now under examination. Therefore, impacts on global warming shall be assessed in the future.

(4) Cooling towers

A cooling tower is an apparatus used to enhance the dissipation of heat from the cooling cycle system by evaporation and convection. Cooling towers are closed systems. Since a closed-cycle system is able to reuse most of its water, it needs to replace only that water lost to the atmosphere by evaporation.

There are many types of cooling towers available. In the "wet" type of tower the water to be cooled comes into close contact with the cooling air and transfers about 75% of the total heat by evaporation. This transfer occurs in the fill.

The water in a cooling tower can be drawn up through the tower by natural or mechanical means. It is then drawn back down through fill by gravity.

The dry cooling tower arrangement, while reducing the amount of plume from the water, requires additional power to operate extra pumps and fans. The circulating water never comes into direct contact with the air but is cooled by convection from pipes within the chimney. In areas where water supplies are available for wet towers, the capital investment for dry towers is prohibitive. However, a lack of water would necessitate this use of a dry tower.

Dry cooling towers give out a lot of heat into the air and will bring increase in air temperature, which in turn, may change the local climate such as wind and rainfall.

Wet cooling tower impacts primarily result from the tower plume that can produce drift deposits, fog, and icing. These plumes are often visible.

(a) Drift deposits

If the surrounding air does not have the capacity to absorb excess moisture, some droplets of the circulating water will escape from the tower. These droplets, called drift, carry with them a salt compound of the chemicals present in the makeup water - concentrated several times. In addition, any chemicals added to the makeup water to control biological and chemical reactions in the cooling system will also be present. Drift deposits occurs in case of the evaporative cooling tower.

Upon being deposited, the salt can damage vegetation through direct contact and indirectly change soil properties. Weathering and corrosion of metals may also occur. The chlorine content of ground water may also be increased.

(b) Fog

Fog is essentially a cloud that has formed at ground level. The conditions that promote water vapor condensation in ground-level can lead to fog conditions with the proper ambient relative humidity when the cooling tower water is added to the surrounding ambient air. Depending upon relative atmospheric stability and wind velocity, this fog can concentrate in a dense pattern over a small area or be dispersed to form a sparse pattern over a wider region.

(c) Visible plumes

In addition to causing ground-level fog, cooling towers can produce visible plumes. When the entrained ambient air produces a mixture above the saturation level of the air, visible plumes normally result. Cold weather and high humidity are the atmospheric conditions most conductive to long visible plumes. Under normal circumstances, a plume usually presents only an aesthetic problem. However, in the presence of high humidity, cold weather, and high wind speed, the plume may be brought down to ground relatively close to the source.

(d) Icing

Icing of roads and structures can result under high humidity, high wind speed, and freezing temperatures. Even when not visible, contact of a moist plume with a colder surface can result in heat transfer to the surface and condensation of the moisture. Under freezing conditions ice will be formed. As the plume moves further away from the cooling tower, however, the possibility of icing occurring decreases.

2.3 Other Impacts

(1) Noise

(a) Construction phase

To construct a steam power plant, various kinds of construction equipment will be used. The applicant should estimate noise for each construction equipment and for each construction phase. Potential noise impacts on people and wild lives shall be evaluated.

(b) Operation phase

The major sources of noise associated with the operation of fossil-fuel power plant that contribute to surrounding environment include:

- Fans, ventilators and pumps attached to boilers, turbines, transformers, etc.
- Cooling towers, natural draft or mechanical draft
- Substation, i.e., transformers and air blast circuit breakers

If an impact is identified, it shall be discussed in terms of its magnitude and effects and methods of noise abatement shall be developed.

(2) Low-frequency vibration of air

Low-frequency vibration of air is a vibration whose frequency is less than 20Hz. Its sources during operation include:

- Vibration of walls of the buildings
- Movement of large amount of air and pressure change
- Pressure change during combustion
- Pulsation of air due to compressors, etc.
- Resonance of attached pipes, etc.

If an impact is identified, it shall be discussed in terms of its magnitude and effects and methods of its abatement shall be developed.

(3) Vibration

(a) Construction phase

The applicant should estimate construction equipment vibration for each construction equipment and for each construction phase. Potential vibration impacts on people and wild lives shall be evaluated.

(b) Operation phase

The major sources of vibration associated with the operation of fossil-fuel power plant that contribute to surrounding environment include:

- Air compressors
- Coal pulverizers
- Pumps and fans

If an impact is identified, it shall be discussed in terms of its magnitude and effects and methods of vibration abatement shall be developed.

(4) Wastes

(a) Construction wastes impacts

Major waste is debris from drilling works. Describe disposal of the debris.

(b) Operation wastes impacts

Major wastes generated in thermal power stations include ash from fuel combustion, particulate, sludge from wastewater treatment equipment, and waste oils and scrap metals generated during periodical inspection and improvement works.

The applicant should discuss the magnitude and significance of the such wastes and describe how to treat and dispose the wastes.

General recycling wastes include:

- Fly ash from electrostatic precipitators of coal-firing boilers
- Ash from coal-firing boilers
- Waste oil from oil change for electric machinery and rotary appliances

- Scrap iron from machinery change
- Particulate from electrostatic precipitators of oil-firing boilers
- Incineration ash of heavy- or crude oil ash
- Gypsum from flue gas desulfurization equipment
- Destruction rubbish from construction works

General disposal wastes include:

- Sludge from cleaning of oil tank
- Waste plastics such as ion-exchange resin
- Sludge from integrated wastewater treatment plant
- Spent acid, and spent lye from chemical cleaning of boilers

(5) Aesthetics

New steam electric generating stations, may be large and complex facilities occupying an area of up to several hundred acres. Cooling towers, stacks, raw material storage and handling area, and other plant components may detract considerably from the surrounding landscape. Particularly in rural and suburban areas, this configuration may represent a significant intrusion on the landscape. Existing industrial areas would be less affected. Measures to minimize the impacts on the environment shall be developed primarily during site selection and design. The applicant consider, as applicable, the following factors to reduce potential aesthetic impacts.

- Existing nature of the area:

  The topography and major land uses in the area of the candidate sites can be important aesthetic considerations. Natural topographic conditions perhaps could serve to screen the plant from public view. A lack of topographic relief will require other means of minimizing impact, such as re-grading or vegetation buffers. Analysis of major land uses may be useful to assist in the design and appearance of the facility. The design of the facility shall reflect the nature of the area in which it is to be placed (i.e., the structures shall be blended into the existing environment as much as possible).
- Proximity of sites to parks and other areas where people congregate for recreation and other activities:

  The location of these areas shall be mapped and presented.
- Transmission lines and transportation system:

  The visual impact of new transmission lines, access roads, railroad lines, pipelines, etc., on the landscape shall be considered.
- Creation of aesthetically pleasing areas:

  In some cases, the development of a power plant will create aesthetically pleasing areas. Screening the facility by vegetation or using the natural topography may improve the appearance of an area. Construction of a cooling lake and development of recreational facilities also may be an improvement to the area.

(6) Electric Power Transmission Systems

The assessment of potential environmental impacts that result from the construction and operation of electric power transmission line systems differs from the assessment of impacts associated with the power station proper, because it is necessary to consider narrow corridors of construction that will total tens or hundreds of kilometers in length for a typical power plant installation, instead of a large central location. Consequently, an applicant may encounter frequent and abrupt changes in topography, soils, vegetation, and other ecological conditions.

Environmental impact considerations include:

- Land use
- Health, safety, and welfare
- Hydrology and water quality
- Air quality
- Noise
- Terrestrial biota
- Aesthetics

(7) Transportation Impacts

(a) Railroads

Operational impacts of coal transport by rail are primarily associated with accidental spillage and windblown loss of coal. Some coal dust may blow off car tops, or sift through the hoppers, which then may be swept off the track by train movement or wind. Dusting of vegetation can reduce palatability of forage to animals and, through reduction photosynthesis, retard vegetation growth. The severity of the problem will be determined by the volume of coal shipped (particularly bituminous coal), whether or not shipments are washed at the mine, whether or not the use of flip top covered cars increase.

(b) Trucks

Impacts to both terrestrial and aquatic ecosystems from truck transport will occur primarily as a result of construction activities and maintenance of haul roads. Dust may be generated by blasting, road grading, and use of unpaved roads by construction equipment. After construction is completed, the primary source of air emissions would be the vehicles using the roads. The extent of impact would depend on the number of vehicles, local meteorology, and topography. The amount of trace metals, particulate, NOx, and SO_2 from truck exhaust is considered small, but exhaust emissions from trucks might eventually reach streams, and waste oil or accidental fuel spills could pollute local waterways.

Also, there is some possibility that coal spillage and subsequent leaching may result from truck transport.

Noise resulting from construction and use of highways would be highly localized, but shall be assessed carefully in the EIA.

Soil erosion and siltation of streams may affect biota or water quality in the stream basins.

(8) Land Reclamation

In case a power plant is to be constructed on the land which is to be reclaimed, EIA for a land reclamation may be required beforehand.

(9) Improvement of Rivers or Lakes, or Construction of Man-made Ponds or Canals

In case rivers, lakes, man-made ponds or canals are used for heat dissipation, EIA for such projects may be required

2.4 Socio-economic Impacts

Introduction of a large new power plant into a community may cause economic and social changes. Therefore, it is necessary for an applicant to understand the types of impacts or changes that may occur so that they can be evaluated adequately in the EIA. The importance of these changes usually depends on the nature of the area where the plant is located (e.g., size of existing community, existing infrastructure). Normally, however, the significance of the changes caused by a plant of a given size will be greater in a small, rural community than in a large, urban area. This is primarily because a small, rural community is likely to have a non-manufacturing economic base and a lower per capita income, fewer social groups, a more limited socio-economic infrastructure and fewer leisure pursuits than a large, urban area. There are situations, however, in which the changes may not significant in a small community and, conversely, in which they may be considerable in an urban area. For example, a small community may have had a manufacturing (or natural resource) economic base that has declined. As a result, such a community may have a high incidence of unemployment in a skilled labor force and a surplus of housing. Conversely, a rapidly growing urban area may be severely strained if a new power plant is located there.

The rate at which the changes occur (regardless of the circumstances) also is an important determinant of the significance of the changes. The applicant should distinguish clearly between those changes occasioned by the construction of the plant and those resulting from its operation. The former changes could be substantial but usually are temporary; the latter may or may not be substantial but normally are more permanent in nature.

During the construction phase, the impact usually be greater if the project requires large numbers of construction workers to be brought in from outside the community than if local, unemployed workers are available. The impacts are well known and include:

(1) Creation of social tension

(2) Demand for increased housing, police and fire protection, public utilities, medical facilities, recreational facilities, and other public services

(3) Strained economic budget in the community where existing infrastructure becomes inadequate

Various methods of reducing the strain on the budget of the local community during the construction phase shall be explored.

During plant operation, the more extreme adverse changes of the construction phase are likely to disappear. Longer run changes may be profound, but less extreme, because they evolve over a longer period of time and may be both beneficial and harmful.

The applicant should document fully in the EIA, the range of potential impacts that are expected and demonstrate how possible harmful changes will be handled.

Major social and economic impacts associated with power plants include:

(1) Relocation impacts

(2) Demographic impacts

(3) Local economic impacts and taxes

(4) Public works and transportation impacts

(5) Land use impacts

(6) Housing impacts

(7) Recreation/culture impacts

(8) Public safety impacts

(9) Educational impacts

(10) Physical and mental health service impacts

(11) Public health impacts

(12) Social services impacts

(13) Social and psychological well-being impacts

(14) Community structure impacts

(15) Organizational impacts

(16) Political impacts

Among them, the more important categories are public services, population impacts, land use impacts, and health impacts.

Appendix 10-5

Thermal Diffusion Prediction

(1) Thermal discharge to sea areas

- Prediction model -

  Numerical simulation model annexed hereto is applied to the prediction.

- Setting of Conditions - see below (Outline)

(2) Thermal discharge to river

- Prediction model

  Numerical simulation model annexed hereto is applied to the prediction. In principle it is the same as that of discharge to sea areas.

- Setting of Conditions - see below (Outline)

  In principle it is the same as that of discharge to sea areas.

(3) Thermal discharge to lakes

- Prediction model

  If lakes are large enough to be considered as sea, this case can be treated as that of discharge to sea areas.

- Setting of Conditions

  Subject to large-scale lakes, details are shown in the paragraph describing setting conditions (Outline) below. In principle it is the same as that of discharge to sea areas.

Setting conditions required for the predictive calculation of thermal diffusion
(Outline)

1. Main field work regarding the predictive calculation

1)Flow survey

Monitoring at each season and annual continuous monitoring

2)Water-temperature (salinity) survey

Monitoring at each season and annual continuous monitoring (for water-temperature)

2. Setting conditions requisite to the predictive calculation

1)Grasp of characteristics of the sea area (i.e. examination of analytical results on flow, water-temperature, etc.)

2)Determination of diffusion coefficient, ambient water-temperature, thickness of thermal effluent layer, heat dispersion coefficient, etc.

3)Setting calculation range, lattice spacing, etc.

3. Principal analyses and results based on the field work data

① vector chart of flow, auto-correlation graph, energy spectrum and diffusion coefficient

② tidal current harmonization analysis

③ fixed point continuous monitoring data of water-temperature and vertical water-temperature distribution chart

④ actual diffusion chart of thermal discharge of neighboring power plant, if any.

4. Selection of predictive model corresponding to characteristics of the sea area, conditions of location and discharging method

To predict the flow and diffusion of thermal discharge, primarily it is necessary to consider well the flow of the sea area, characteristics of diffusion and regional features (such as neighboring power plant, laver farm, fishery facilities, river etc.). Then also taking into consideration conditions of location and discharging method of thermal effluent, an appropriate predictive model, which could properly interpret the behavior of flow and diffusion of thermal discharge into sea areas, should be selected.

Major predictive methods with respective applicable predictive model are shown as follows.

(1) Simulation analysis by numerical model

In this method, diffusion of thermal discharge is predicted by numerical analysis of three equations using computer; (1)hydrodynamic equation of momentum, (2)equation of continuity, which both describe the flows of thermal discharge and the sea area, and (3)equation of heat dispersion, which takes into consideration heat balance between atmosphere and sea surface. In the analysis many factors affecting the behavior of flow and diffusion in sea areas (such as conditions of discharge, position of the outlet, topographic features of coast and seabed, weather and hydrographic conditions) are taken into account. For computing, it is required to set the following conditions that include regional features in advance.

1) Specification of power plant : discharge effluent velocity and flow rate, temperature rise, and positions, shapes and method of intake and discharge system
2) Preparation of topographic model : lattice spacing for computing, and drawing actual and future topography data of both land and sea areas
3) Time scale : energy spectrum of sea areas and calculation of prevailing cycle
4) Conditions regarding flow of field : both tidal current and constant current components of current direction, velocity, etc.
5) Diffusion coefficient : examination of isotropy and aeolotropy
6) Ambient water-temperature : setting based on water-temperature data from fixed point continuous measurement
7) Thickness of thermal effluent layer : thickness evaluation by processing monitord data of water-temperature into vertically dimensionless. In case that no monitored data can be obtained, calculation would be performed by an experiment etc.
8) Heat dispersion coefficient : determination from setting requisite values including temperature, humidity, wind velocity, amount of cloud (a statistical value reported on a climate table) and data of ambient water-temperature, on the basis of yearly fluctuation of water-temperature.
9) Recycling rate : calculation of mixing rate
10) River water conditions : setting of flow rate based on statistical data from flow chronology as well as on monitored results

(2)Hydraulic model experiment

This predictive method with hydraulic model experiment represents a phenomenon of flow and diffusion with the thermal discharge. Topography of land and sea areas and a discharging structure (a plant) geometrically similar to the original form are all reproduced in an experiment tank where both the momentum and the diffusion behavior of fluid should be maintained similar ones to original phenomena.

This method is usually used for power plants adopting "a sub-marine discharging system" and it is an effectual measure for such cases as it is difficult to comprehend well the phenomena with the predictive calculation by two-dimensional numerical model. In this case, as it is required to set conditions of the virtual outlet for the predictive calculation, the conditions should be set by experiment. For experiment, it is required to set the following conditions that include regional features in advance.

1) Specification of power plant : Discharge velocity and flow rate, temperature rise, and positions, shapes and method of intake and discharge system
2) Actual flow of the site and characteristics of the water-temperature : setting such conditions as flow of field, water-temperature, etc., based on the results of field work data. The process is just like as the predictive calculation.
3) (horizontal and vertical) reduced scale of the model : preparation of a hydraulic model and setting discharge flow rate and velocity, observed time, and density difference of thermal discharge.
4) Virtual outlet : setting the following conditions on an experiment subjected to near field of the outlet.
   - position of the virtual outlet
   - width of the virtual outlet
   - shape and thickness of the thermal effluent layer
   - temperature rise and discharge velocity
5) River water conditions : setting of flow rate based on statistical data from flow chronology as well as on monitored results

The above-mentioned setting conditions (Outline) is pertaining to the predictive calculation of thermal diffusion by two-dimensional numerical model which is now generally used.

Thermal diffusion prediction simulation model procedure

1. Discharge velocity formula

Discharge velocity formula is shown as the following equation of momentum and equation of continuity.

Equation of Momentum

$$\frac{\partial M}{\partial t}+\frac{\gamma}{\alpha^2}\frac{\partial}{\partial x}\left(\frac{M^2}{S+H_w}\right)+\frac{\gamma}{\alpha^2}\frac{\partial}{\partial y}\left(\frac{MN}{S+H_w}\right)$$

$$=-g\cdot(S+H_w)\frac{\partial S}{\partial x}+A_x\frac{\partial^2 M}{\partial x^2}+A_y\frac{\partial^2 M}{\partial y^2}-\tau_x \quad \cdot \text{(1)}$$

$$\frac{\partial N}{\partial t}+\frac{\gamma}{\alpha^2}\frac{\partial}{\partial x}\left(\frac{MN}{S+H_w}\right)+\frac{\gamma}{\alpha^2}\frac{\partial}{\partial y}\left(\frac{N^2}{S+H_w}\right)$$

$$=-g\cdot(S+H_w)\frac{\partial S}{\partial y}+A_x\frac{\partial^2 N}{\partial x^2}+A_y\frac{\partial^2 N}{\partial y^2}-\tau_y \quad \cdot \text{(2)}$$

Equation of Continuity

$$\frac{\partial S}{\partial t}+\frac{\partial M}{\partial x}+\frac{\partial N}{\partial y}=0 \quad \cdots\cdots\cdots\cdots\cdots \text{(3)}$$

t :	Time
x, y, z :	Direction of x, direction of y and direction of z
M, N :	Discharge flow rate in direction of x and direction of y
S :	Water level
g :	Gravity acceleration
A_x, A_y :	Coefficient of horizontal vortex viscosity in direction of x and direction of y
α :	$\alpha=\int_0 f(\eta)\,d\eta$
γ :	$\gamma=\int_0^1 f^2(\eta)\,d\eta$
	$f(\eta)$ = Vertical velocity distribution chart
η :	$\eta=\dfrac{S+z}{S+H_w}$
H_w :	Thickness of Thermal discharge effluent

τ_x, τ_y : Interfacial resistance in x and direction of y

$$\tau_x = \{f(\eta)\}^2 \cdot K_f \cdot \frac{M\sqrt{(M^2+N^2)}}{\alpha^2 (S+H_w)^2}$$

$$\tau_y = \{f(\eta)\}^2 \cdot K_f \cdot \frac{N\sqrt{(M^2+N^2)}}{\alpha^2 (S+H_w)^2}$$

K_f = Interfacial resistance coefficient

$\eta = 1$

2 . **Constant-current velocity formula**

Constant-current velocity formula is shown as the following equation of momentum and equation of continuity.

Equation of Momentum

$$\frac{\partial M}{\partial t} + \frac{\partial}{\partial x}\left(\frac{M^2}{S+H}\right) + \frac{\partial}{\partial y}\left(\frac{MN}{S+H}\right)$$

$$= -g \cdot (S+H)\frac{\partial S}{\partial x} + A_x \frac{\partial^2 M}{\partial x^2} + A_y \frac{\partial^2 M}{\partial y^2} - \tau_{bx} \quad \cdot (4)$$

$$\frac{\partial N}{\partial t} + \frac{\partial}{\partial x}\left(\frac{MN}{S+H}\right) + \frac{\partial}{\partial y}\left(\frac{N^2}{S+H}\right)$$

$$= -g \cdot (S+H)\frac{\partial S}{\partial y} + A_x \frac{\partial^2 N}{\partial x^2} + A_y \frac{\partial^2 N}{\partial y^2} - \tau_{by} \quad \cdot (5)$$

Equation of Continuity

$$\frac{\partial S}{\partial t} + \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} = 0 \quad \cdots\cdots\cdots\cdots\cdots (6)$$

H : the depth of water

τ_{bx}, τ_{by} : Frictional resistance in bottom of the sea in x and direction of y

$$\tau_{bx} = K_b \cdot \frac{M\sqrt{(M^2+N^2)}}{(S+H)^2}$$

$$\tau_{by} = K_b \cdot \frac{N\sqrt{(M^2+N^2)}}{(S+H)^2}$$

K_b = Frictional coefficient in bottom of the sea

Other symbols are the same as those described in discharge velocity formula.

3. **Thermal diffusion**

Thermal diffusion formula is shown as follows.

$$\underbrace{\frac{\partial T_s}{\partial t}}_{\text{Time}} + \underbrace{\left(U + \frac{\delta}{\beta} U_s\right)\frac{\partial T_s}{\partial x} + \left(V + \frac{\delta}{\beta} V_s\right)\frac{\partial T_s}{\partial y}}_{\text{Advection}}$$

$$= \underbrace{K_x \frac{\partial^2 T_s}{\partial x^2} + K_y \frac{\partial^2 T_s}{\partial y^2}}_{\text{Diffusion}} + \underbrace{\frac{Q_0 - Q_1 T_s}{c \rho H_w}}_{\text{Heat dispersion}} \quad \cdots\cdots\cdots (7)$$

- t : Time
- T_s : Sea-surface Temperature
- U , V : Velocity in direction of x and direction of y
- U_s, V_s : Sea-surface velocity in direction of x and direction of y by discharge thermal effluent
- K_x, K_y : Diffusion coefficient in direction of x and direction of y
- Q_0 : Heating factor unrelated to water temperature
- Q_1 : Heat dispersion coefficient to Atmosphere ※1
- c : Seawater specific heat
- ρ : Seawater density
- H_w : Thickness of thermal discharge effluent layer (constant value)
- β, δ : Parameter showing vertical distribution chart of thermal discharge effluent

$$\beta = \int_0^1 h(\eta)\, d\eta$$

$h(\eta)$ = Vertical distribution chart of water temperature

$$\delta = \int_0^1 f(\eta) \cdot h(\eta)\, d\eta$$

$f(\eta)$ = Vertical distribution of velocity

Appendix 11.1 Operational and Maintenance Management of Thermal Power Plants

1. Operational Management

For thermal power plants, maintaining and improving the thermal efficiency is a matter of the highest priority and also the most important subject from the viewpoint of cost reduction of the electricity generation.

Among factors affecting the thermal efficiency, apart from uncontrollable ones, some factors which are subject to operational conditions, such as conditions of steam, the vacuum degree of condenser and conditions of combustion, can be effective in preventing deterioration of thermal efficiency to some degree by properly control.

The thermal efficiency in a thermal power plant decreases with a generating output. While the efficiency is 39 - 40 % under the rated output, it decreases to 36 - 37 % under the half output. This is because the turbine efficiency falls along with the downslide of output and not because of boiler efficiency. Even when the output decreases, the boiler efficiency is almost the same as that under the rated output. Regarding boilers, main operational conditions which affect the thermal efficiency are temperature of flue gas and excessive air ratio, while regarding turbines, such conditions include the vacuum degree of condenser, pressure and temperature of main steam and temperature of reheated steam. The concept of improvement of the thermal efficiency is that, if causes of the deteriorated thermal efficiency can be identified through investigation on various elements, efforts should be made to minimize the undesirable effect by these causes.

(1) Rise in Temperature of the Main Steam

As one of measures to improve the thermal efficiency of power plants, it is advisable to raise enthalpy at a turbine inlet. Since it can be considered that the turbine inlet enthalpy is determined by steam temperature and pressure, it is recommended not to lower this enthalpy under the designed value.

(2) Air Ratio

From the viewpoint of boiler heat loss, the lower air ratio is the better. If it is heightened, the heat loss with stack gas will increase along with the increment volume of stack gas. If the ratio is lowered, loss of the unburned portion due to incomplete combustion will increase more or less. The best way for the boiler efficiency is to lower the air ratio by measuring and controlling the concentration of O_2 in stack gas at a economizer outlet.

(3) Flue Gas Temperature

High temperature of stack gas at an outlet of air heater means heat loss, because the heat in the stack gas is uselessly wasted. Therefore, it is desirable to lower the stack gas temperature down to the very limit value within a range that corrosion of air pre-heater would be prevented. For this purpose, both air leak and reduction or blocking of heat exchanger area due to corrosion must be prevented by monitoring the concentration of SO_3 and the dew point of stack gas and also by controlling performance of the air heater.

(4) In-house Consumption of Electric Power

In order to improve the thermal efficiency of power transmission, it is necessary to save the amount of electric power consumed in a plant. Therefore, it is required to cut back on wastes of electric power in the plant by installing controllers of rotation speed on each of feed water pumps, air blowers etc., saving the number of facilities at work at low load, and/or using appropriate auxiliary facilities in addition.

(5) Vacuum Degree of Condenser

The most influential factor for the turbine efficiency is the vacuum degree of condenser. As the vacuum degree of condenser is dependent on the temperature of cooling water, the turbine efficiency can be improved by taking appropriate measures to keep and control the cooling efficiency of condenser, such as cleaning of heat transfer tubes, corrosion precaution of the tubes, maintenance of the cooling tower, etc.

Operators are obligated to endeavor to maintain and improve the efficiency of power generation facilities by operating with proper operational conditions regarding above-mentioned important elements for the adopted measures.

2. Maintenance Management

In order to operate thermal power plants stably for many years, it is always required and important an operational control of equipment and a regular management of precautionary maintenance including periodical inspections. The following indicates the main work of operators and that of maintenance and repair workers.

(1) Operation

1) Adjustment of Unit Output

The main work is to monitor and adjust the steam pressure to keep it at a designated value while keeping the characteristic values of each facility within the limits, all through the operation, from starting up the boiler to stopping down and from the lowest output to the rated output.

2) Patrol of Equipment

Routine patrol of facilities should be carried out in order to maintain good operational conditions of facilities and also to detect any abnormal state in earliest stages. If any abnormality is found, immediate check and repair or appropriate measures should be required, and the normal operation without any maintenance should not be continued even though any failure or stoppage has not occurred yet.

3) Regular Checking Test

In order to confirm functions of protectors and spare devices, checking tests should be regularly carried out weekly and monthly. Checking burner chips and switching strainers of the fuel system should be regularly carried out.

In addition, it is also necessary to implement other tests which are executed at the time of regular checking, including hydrostatic test of boiler, performance test of safety valves of boiler, and function tests of each protective, precautionary and alarm devices (such as a emergency fuel-cut device).

4) Keeping Operational Targeted Values and Heat Management

Operational targeted value is a value for operating control which is determined by comprehensively examining various aspects including safety, environmental preservation and economy.

The major items are as follows:

* Changing rate of output
* Number of burners

* Number of auxiliary devices at work
* Temperature and pressure of steam
* Concentration of O_2 in stack gas at the economizer outlet
* Metal temperature of air pre-heater

There are many items of the operational targeted value. It is necessary to control the operation to keep targeted values by means of automatic controllers and/or supplementary manual operation. In case that an operational targeted value cannot be kept, the cause should be cleared up and the corresponding measures must be taken immediately.

(2) Precautionary Check and Maintenance

Proper precaution check as well as adequate maintenance are indispensable for safe operation of facilities and also for calling forth full functions and performances of facilities. For this purpose, routine patrol and checking and regular inspection should be carefully and fully carried out. In addition, it is also important taking prior measures for maintenance and repair based on a secular change management (prediction by historical changes), and detecting abnormal values in early stages by continuous monitoring of operation data as well as.

1) Daily Check

An operator should patrol around the facility at fixed time everyday. On the other hand, the department of maintenance and repair should also carry out inspection and checking tours daily. It is necessary to make efforts to find abnormality of facilities as earlier as possible with this double-checking system. Inspection and checking are confirmed with a check sheet at the patrol. Frequency of checking should be once or more a day. Details of daily checking are shown in **Table 1.**

2) Regular Checking

As regular checking, both disassembling/opening check, and resetting off and adjusting tests are regularly required for boiler and turbine facilities and also for their accessory equipment at a fixed interval.

3) Precautionary Check based on the Operation Data

Secular change management of the major operational data provides one of effective measures to appreciate the secular deterioration of facilities and also to find out any abnormality. As both two power plants have been operated for years and it is considered that the deterioration is fairly advancing, following measures are required for prolonging the life time.

a. Appropriate Maintenance and Management

The past failure/trouble records of the equipment should be accumulated. The inclination of deterioration of the facilities could be appreciated by analyzing and evaluating the records. Precautionary check and maintenance management should be then carried out based on it.

Table 1 Items of Daily Inspection and Checking

Facilities	Item
Boiler safety valve	* Leakage of steam from the seat part
Main pipes	* Abnormality of hangers * Leakage of steam from pipes * Vibrations of pipes
Furnace	* State of combustion * Abnormality in the furnace
Main rotary machines (excluding a steam turbine)	* Vibrations, abnormal sound and rise in temperature of the main body * Leakage of steam from the ground part * Oil temperature and oil surface of the bearing, and leakage of oil
Main valves	* Vibrations and abnormal sound of the valve body * Leakage of steam from the ground and seat parts of the valve * Abnormality of the working source
Steam turbine	* Vibrations and abnormal sound * Leakage of steam from the compartment * Looseness of bolts and nuts * Vibrations of the bearing, abnormal sound, overheat, and the state of exhaust oil
Heat exchanger etc.	* Leakage of steam * Water level

b. Implementation of Life Management, Applying the Facilities Diagnosis Techniques

The remaining life of facilities should be properly managed by appreciating the actual state of their deterioration.

c. Renewal of Facilities

Deteriorated parts should be replaced and facilities should be renewed at the appropriate time. Before replacement of parts or renewal of facilities, it is necessary to discuss bringing in any new materials, taking into consideration maintenance and economical efficiency.

Appendix 11-2 Sulfur Removal at Oil Refinery or at Power Plant

A) Nationwide Heavy Oil Balance

Total crude oil refined in Iran (1993 - 1994) 415,133,000 bbl = 66,000,000 m^3 (#51)
Heavy oil production in 1990 230,900 bbl/day = 36,700 m^3/day (#83)
or 31.2% of all oil products (#83)

Heavy oil produced in 1993, by assuming to be 31.2% of oil refined
66,000,000 x 0.312 = 20,600,000 m^3 / year

Heavy oil consumption in the power plants in 1993 (#24) 5,786,000 m^3 / year
or 5,786,000 x 100 / 20,600,000 = 28.1 % of produced heavy oil in Iran.

B) Tabriz Heavy Oil Balance

The Tabriz Power Plant receives heavy oil from the Tabriz NIOC refinery by 5 km piping.

Tabriz Refinery : Crude oil processing capacity = 35,000,000 bbl/year (#51)
or 5,565,000 m^3/year

Heavy oil production, if 31.2% of crude is heavy oil = 1,736,000 m^3/year

Tabriz Power Plant Heavy oil consumption: two units at full capacity
= 65 x 24 x 365 x 2 ≒ 1,100,000 m^3/year
≒ 63 % of the production

C) Esfahan Heavy Oil Balance

The Esfahan Power Plant receives heavy oil from the Esfahan NIOC Refinery by piping reportedly to be in use from October, 1998.

Esfahan Refinery : Crude oil processing capacity = 125,000,000 bbl/year (#51)
or 19,870,000 m^3/year

Heavy oil production, if 31.2% of crude is heavy oil = 6,170,000 m^3/year

Esfahan Power Plant Bz consumption in 1995 = 781,000 m^3 (#30)

Montazeri Power Plant Az consumption in 1995 = 1,228,000 m^3 (#30)

Montazeri Power Plant's capacity will be doubled into 1600 MW quite soon.

Total heavy oil consumption in the Esfahan region = 3,237,000 m^3 at max.
52 % of the production

Az and Bz are heavy oil with differences of viscosity (M/M of the 1st F/W).

Sulfur % are Az 3.4 and Bz 3.13 (#Report of the JICA Preparatory Team).

During the Study period, Esfahan had actually used natural gas supplying around 50 to 90% of fuel requirement (remaining by heavy oil) in summer from the middle of June to the middle of October 1998. Costs of fuels are US$40/1000 m^3 of import natural gas (#99, 9/26/98) and US$7.69/barrel of export heavy oil (#99, 2/16/98) in Iran. They correspond respectively US$4.5 and 4.8 per million kcal of combustion heat. Natural gas is cleaner and a little less expensive.

D) Sulfur Removal Costs

Crude oil contains wide range of hydrocarbons which mixtures result various oil products such as LPG, naphtha, gasoline, gas oil, diesel, heavy oil, asphalt, etc. If the power sector uses natural gas instead of heavy oil, the Iranian oil sector has to convert excess heavy oil to salable, lighter and cleaner fuel, such as gasoline, gas oil, or else, otherwise it has to export high sulfur heavy oil. Export seems quite difficult in the current world oriented to pollution abatement, although not impossible.

The conversion of heavy oil to lighter products involves cracking of the heavy oil, thermally, or with hydrogen and catalyst at high pressure. In any conversion method, various complicated sulfur compounds in heavy oil are cracked to less complicated compounds, of which a substantial portion is hydrogen sulfide (H_2S). H_2S is later converted to sulfur for storage and sales if there is a market.

In essence, construction and operational costs shall be studied including Hydrogen Plant, Cracking Plant, H_2S Removal Plant and Sulfur Plant for sulfur reduction in the oil sector. The costs incurred by the power sector is only for a stack gas cleaning or flue gas desulfurization (FGD) plant, if sulfur is reduced in the sector.

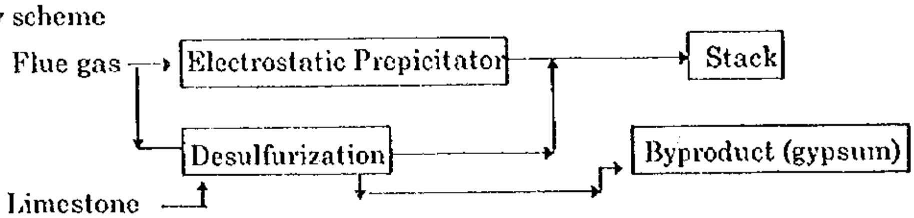
The case of Tabriz, (368 MW x 2 units, total fuel oil requirement 1,000,000 m^3) in a year, is selected to estimate roughly the difference between the power sector and the oil sector to be incurred for investment and operational costs of the sulfur reduction. The reduction is assumed here to be 50%: in the power plant 1600 ppm to 800 ppm and in the oil sector 3.2% to 1.6%. Rough estimation is tried to obtain initial investment costs and operational consumption requirements as follows:

① Power sector

Flue gas is separated into two parts; one sent to a desulfurization unit and the other to the stack directly. SOx in the first portion of the flue gas is removed by the desulfurization unit. The process has many varieties as described in Appendix 3-2.

Most commonly used in a power sector in the world is the limestone scrubbing process. Limestone slurry is to scrub out SOx and to by-produce calcium sulfate or gypsum powder which is used for wall board manufacturing or wasted in pile as it is. The second portion of the flue gas is to mix with the first portion and sent to the stack.

Flow scheme



Flue gas generated in one power unit is roughly 1.1 million m^3/hour. For the independent operation of each power unit, one desulfurization unit is required for one power unit. Assuming 56 % of the flue gas is sent to the desulfurization unit with 90 % of SO_2 removal and 44 % of the gas is sent to the stack via an electrostatic precipitator, SO_2 contents in the stack gas will be about 800 ppm.

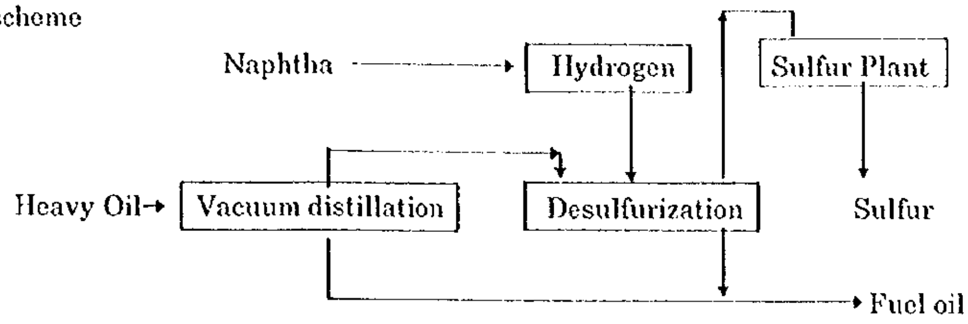
The soot loading at the precipitator outlet should be 150 mg/m^3 at the stack. By assuming the soot loading is 740 mg/m^3 of flue gas at the entrance of the precipitator (the maximum value monitored by the Study) and by assuming soot removal at the desulfurization unit is 100%, the removal efficiency at the precipitator should be 100 x 150 / (740 x 0.44)=46%. The removal efficiency of 50% would be enough to meet the drafted emission standard.

Investment cost: two desulfurization units -		US$40,000,000
two electric precipitators -		18,000,000
Consumption of two units:	Electricity	4,000 kw
	Limestone	73 ton/day

② Oil sector

Heavy oil (125 m^3/hour) is distilled under vacuum producing distilled portion and bottom residue. The distilled portion (80 m^3/hour) is desulfurized catalytically under high temperature and pressure in the stream of hydrogen producing fuel oil of very low sulfur contents (0.2%). The fuel oil and the bottom residue is blended to make required oil of 1.6% sulfur contents. Hydrogen sulfide produced in the desulfurization unit is decomposed to produce elemental sulfur which is used for production of sulfuric acid or piled as sulfur blocks.

Flow scheme



Initial investment costs and consumption are roughly estimated as in the following table by referring "New Refinery Processes (in Japanese), 1984, Published by Saiwai Shobo".

	Vacuum Distillation	Desulfu-rization	Hydrogen	Sulfur	Total
Initial Invest-ment, x1000 US$	17,500	83,400	16,700	3,400	121,000
Electricity, kw	500	1100	100	neglect	1,700
Steam, t/h	5	3.5	--	neglect	8.5
Naphtha, t/h		--	1.2	--	1.2
Fuel Oil, kg/h		800	1000	--	1,800

The oil sector apparently needs more operators than the power sector to operate the complicated process scheme of the sulfur reduction. Water requirement is neglected from the above estimations.

Appendix 11-3 CMB (Chemical Mass Balance) Method

1. Outline of CMB Method

CMB (Chemical Mass Balance) method is a type of receptor model or statistical model to estimate the contributions from sources to ambient SPM concentration. The sources of SPM can be divided into artificial sources and natural ones. The former includes the different kinds of factories, various types of motor vehicles, etc. The latter includes soil particles, sea salts, and others. One special feature of SPM component is the high contribution by natural sources of wide varieties and it is, therefore, very difficult to establish a physically complete model for estimating SPM. Hence, the CMB method provides an alternative way to effectively estimate the contributions by artificial and natural processes.

The particles are categorized into primary particles and secondary particles. The primary particles are those emitted in particulate form, but the secondary particles are those emitted in gaseous phase and then shaped to particulates in the air. For example, some parts of SO_2 are converted to SO_4 and finally to sulfuric acid mist or sulfate particulates. CMB method targets the primary particles and the contributions by the secondary particles are directly evaluated from their chemical components of ambient SPM.

The mathematical formulation of CMB method is explained as follows. The receptor model for estimating the contributions by pollution sources is based on the law of conservation of mass. Assuming that there are (p) numbers of emission sources and that there is no interaction between particulates in resulting changes of mass balance, SPM concentration (C) measured at the receptor is obtained by taking the sum of contributions (S_j) of each emission source as in equation (1).

$$C = \sum_{j=1}^{p} S_j \qquad (1)$$

Similarly, concentration (C_i) of component (i) in the SPM is expressed by equation (2). Here (a_{ij}) is the mass fraction of source contribution (j) possessing component (i) at receptor.

$$C_i = \sum_{j=1}^{p} a_{ij} S_j \qquad (2)$$

An equation is set up for each component by assuming that (n) numbers of components are analyzed at the sources and receptors. If the number (n) is greater than or equal to a number (p), we could obtain the answer by solving the set of (p) set of linear equations.

When the number (n) is greater than (p), a set of accurate values is obtained by minimizing the value (χ^2) expressed in equation (3).

$$\chi^2 = \sum_{i=1}^{n} \frac{\left(C_i - \sum_{j=1}^{p} a_{ij} S_j\right)^2}{w_i^{-2}} \quad (3)$$

Here (w_i) are the weights according to the extent of errors in measurement.
Equation (4) is the matrix from expression of equation (2).

$$C=AS \quad (4)$$

Here (C) is n-dimensional vector of component concentration, and (A) is n by p matrix of mass fraction of sources, and (S) is n-dimensional vector of contributions by sources.

Generally, the solution by the least squares method is as the followings.

$$S=({}^{t}AWA)^{-1}\,{}^{t}AWC \quad (5)$$

Here, (W) is a diagonal matrix with diagonal components of w_i^2. ${}^{t}A$ is transpose of matrix A and X^{-1} is inverse matrix of matrix X. Errors of estimations for the source contributions depend on the way the weights (w_i) are chosen.

2. Example of CMB Method

(1) Analysis of Elemental Composition

Following (cited from "Analysis and Simulation of SPM Pollution" by Japan Environment Agency 1987) are to show how to evaluate source contributions with chemical element compositions of ambient SPM and various sources. The chemical element compositions of ambient SPM and sources used are compiled in **Table 1.**

Ambient SPM samples were collected during 2 weeks by low volume air samplers for each season at 8 selected places in Osaka Prefecture. The Prefecture is the second populated one in Japan. The 39 chemical elements in the samples were analyzed by Instrumental Neutron Activation Analysis (One of peaceful utilization of nuclear energy), and the elemental carbon (EC) and the organic carbon (OC) were done by Thermal Manganese Oxidation Method.

Target sources were assumed as soil, sea salt, steel factory, oil burning facility, incineration facility, and diesel vehicle. The chemical compositions of the sources were determined from the actual measurement and the literature values.

Table 1 Elemental Composition of Ambient SPM and PM Sources

	Ambient		Soil		Sea Salt		Steel		Oil Burning		Incineration		Diesel Vehicle	
	Concentration	Content	Content	E.F.	Content	E.F.	Content	E.F.	Content	E.F.	Content	E.F.	Content	E.F.
	ng/m^3	%	%		%		%		%		%		%	
Na	583	1.5	1.38	0.94	30.4	21	1.36	0.92	1.00	0.68	12.0	8.2	0.0150	0.010
Al	498	1.3	6.43	5.1	<0.0001	<0.0001	0.999	0.79	0.210	0.17	0.420	0.33	0.0610	0.048
Si	1220	3.1	-	-	0.00870	0.0028	-	-	-	-	-	-	-	-
S	2100	5.3	-	-	2.60	0.49	4.79	0.90	9.60	1.8	13.0	2.4	3.70	0.70
Cl	707	1.8	0.0584	0.033	55.1	31	3.41	1.9	0.0920	0.051	27.0	15	0.0660	0.037
K	520	1.3	1.91	1.5	1.10	0.84	1.32	1.0	0.0850	0.065	20.0	15	0.0370	0.028
Ca	415	1.0	1.88	1.8	1.17	1.1	4.51	4.3	0.0850	0.081	1.10	1.0	0.0610	0.058
Sc	0.0881	<0.0001	<0.0001	4.1	<0.0001	<0.0001	<0.0001	0.59	<0.0001	0.040	<0.0001	0.21	<0.0001	0.010
Ti	54.8	0.14	0.468	3.4	<0.0001	<0.0001	0.100	0.72	0.0740	0.53	0.0900	0.65	0.0110	0.079
V	10.8	0.027	0.00477	0.18	<0.0001	<0.0001	0.0125	0.46	0.920	34	0.00270	0.099	<0.0001	0.028
Cr	9.27	0.023	0.00726	0.31	<0.0001	<0.0001	0.316	13	0.0210	0.89	0.0850	3.6	<0.0001	0.029
Mn	40.1	0.10	0.0709	0.70	<0.0001	<0.0001	2.20	22	0.0120	0.12	0.0330	0.33	0.00120	0.012
Fe	657	1.7	3.21	1.9	<0.0001	<0.0001	15.7	9.5	0.460	0.28	0.610	0.37	0.0360	0.022
Co	0.584	0.0015	<0.0001	0.58	<0.0001	<0.0001	0.00440	3.0	0.00310	2.1	0.00210	1.4	<0.0001	0.088
Ni	6.46	0.016	0.00300	0.18	<0.0001	<0.0001	0.290	18	0.490	30	-	-	0.00180	0.11
Cu	36.0	0.091	0.0400	0.44	<0.0001	<0.0001	0.370	4.1	-	-	0.360	4.0	-	-
Zn	192	0.48	0.0611	0.13	<0.0001	<0.0001	5.15	11	0.0400	0.082	2.60	5.4	0.0560	0.12
As	6.49	0.016	<0.0001	0.034	<0.0001	<0.0001	0.0103	0.63	0.00230	0.14	0.0150	0.91	<0.0001	0.016
Se	1.46	0.0037	-	-	<0.0001	<0.0001	0.00511	1.4	0.00480	1.3	-	-	<0.0001	0.027
Br	5.82	0.015	<0.0001	0.027	0.190	13	0.0144	0.98	<0.0001	0.058	0.0830	5.6	0.0199	1.3
Rb	1.53	0.0039	0.00825	2.1	<0.0001	0.091	0.00768	2.0	-	-	0.0260	6.7	-	-
Ag	0.363	<0.0001	0.00310	3.4	<0.0001	0.0095	0.00542	5.9	-	-	0.0150	16.	-	-
Cd	6.69	0.017	-	-	<0.0001	<0.0001	0.0252	1.5	0.0240	1.4	0.0500	3.0	-	-
Sn	20.1	0.051	-	-	<0.0001	<0.0001	0.281	5.5	-	0.043	0.300	5.9	-	-
Sb	6.30	0.016	<0.0001	0.017	<0.0001	<0.0001	0.00900	0.57	<0.0001	-	0.0610	3.8	<0.0001	0.014
I	5.37	0.014	-	-	0.170	13	-	-	-	-	-	-	<0.0001	0.065
Cs	0.177	<0.0001	<0.0001	0.82	<0.0001	0.0065	-	-	-	-	0.00120	2.7	-	-
Ba	14.3	0.036	0.0535	1.5	<0.0001	0.0024	-	-	-	-	0.0390	1.1	-	-
La	0.587	0.0015	0.00267	1.8	<0.0001	<0.0001	<0.0001	0.19	-	-	<0.0001	0.52	<0.0001	0.013
Ce	0.778	0.0020	0.00611	3.1	<0.0001	<0.0001	0.00687	3.5	-	-	0.0170	8.6	<0.0001	0.056
Sm	0.0446	<0.0001	<0.0001	3.7	<0.0001	<0.0001	<0.0001	0.19	<0.0001	6.7	<0.0001	0.41	<0.0001	0.022
Eu	0.0143	<0.0001	<0.0001	2.4	-	-	-	-	-	-	-	-	-	-
Yb	0.0414	<0.0001	<0.0001	2.4	-	-	-	-	-	-	-	-	-	-
Lu	0.00324	<0.0001	<0.0001	3.1	-	-	-	-	-	-	-	-	-	-
Hf	0.0473	<0.0001	0.00105	8.8	-	-	-	-	-	-	-	-	-	-
Ta	0.0437	<0.0001	<0.0001	1.5	-	-	-	-	-	-	<0.0001	0.73	-	-
W	1.22	0.0031	<0.0001	0.13	<0.0001	<0.0001	0.00474	1.5	-	-	-	-	-	-
Pr	85.9	0.22	-	-	<0.0001	<0.0001	1.44	6.6	0.0330	0.15	1.70	7.8	0.0490	0.23
Th	0.0991	<0.0001	<0.0001	3.6	<0.0001	<0.0001	-	-	-	-	-	-	<0.0001	0.048
EC	7070	18	1.00	0.056	<0.0001	<0.0001	0.500	0.028	30.0	1.7	0.500	0.028	68.0	3.8
OC	3610	9.1	-	-	-	-	-	-	-	-	-	-	-	-

Note) E.F.: Effective Factor=Contents in Source/Contents in Ambient
Source Contents not less than 1.0 %: Underlined, E.F. not less than 2.0: in Bold Letter
Shaded Row: Tracer Elements Selected
EC: Elemental carbon, OC: Organic carbon

(2) Selection of Tracer Elements

Tracer elements which are characteristic for each emission source, must be chosen for CMB method. One indicator for the choice is elemental contents in the sources. The contents having not less than 1 % are underlined in Table 1. Another indicator is Effective Factor (E.F.). It is defined as follows:

$$E.F. = X_{i,source} / X_{i,ambient}$$

$X_{i,source}$: Content of Element (i) in Sources

$X_{i,ambient}$: Content of Element (i) in Ambient

The elements with large E.F. values for each source are given below.

Soil:	Hf, Al, Sc, Sm, Th, Ti, Ce,	Sea Salt:	Cl, Na, Br, I,
Steel:	Mn, Ni, Cr, Zn, Fe, Pb,	Oil Burning:	V, Ni,
Incineration:	Ag, K, Cl, Ce, Na, Pb, Rb, Br, Zn,	Diesel Vehicle:	EC,

Cl, Br, and Iode were eliminated because of their possible loss by sublimation or vaporization in the atmosphere. Hf, Th, Ce, Ni, Pb, Ag, and Rb were eliminated because of inaccurate contents values in certain sources. Finally, twelve elements: Na, Al, K, Sc, Ti, V, Cr, Mn, Fe, Zn, Sm, and EC, are selected as the tracer elements for the CMB calculation.

(3) Source Contributions to Ambient SPM

The concentrations of the twelve elements in ambient SPM are input to Ci of Equation (2). The contents of the twelve elements of eight sources are input to aij. By solving the equation, the contributions from the sources were obtained as in Table 2.

Table 2 Source Contributions to Ambient SPM

Sources	Contributions $\mu g/m^3$	Contributions %
Soil	8.7±0.8	22.0
Sea Salt	0.7±0.3	1.8
Steel	2.1±0.3	5.3
Oil Burning	1.1±0.2	2.8
Incinration	1.8±0.4	4.6
Diesel Vehicle	9.9±1.8	25.0
Unknown	15.2	38.5
Total	39.5	100.0

Around 60 % of the contributions were identified by the CMB method, and the contributions of diesel vehicle and soil particles exceeded 20 %, respectively.

References

01 - 40 Collected by JICA in March and August, 1996
41 - 50 Possessed by SUR and TEE originally, except duplications with the above
51 - 60 Collected by the JICA Team during the First Field Work
61 - Collected by the JICA Team after the First Field Work

Note: pp total number of pages in the reference
p specific description on the page numbered

01
Title: Framework Legislation for Environmental Management in I. R. Iran
Notes: pp6; policy, description mostly of water, land, wildlife, etc.

02
Title: Number of Power Plants in The Country and Their Production during 1995
Notes: 1 sheet; total 77million MWh in 1995

03
Title: National Power Plants Development up to 1999 - Second 5 Year Plan
Notes: 1 sheet; nothing for Tabriz and Esfahan

04
Title: Organizational Chart of Deputy Minister for Energy Affairs; 1 sheet

05
Title: Waste Water Treatment Layout - Tavanir 1170 MW; 1 drawing
Source: CCPP-Iran, Siemens

06
Title: Fuel Gas Specification with Different Source Origin; 1 sheet
Source: Gilan Power Station

07
Title: Laboratory Gas Chromatography Report
Source: Shahid Hashemi Nedoad Gas Treatment Plant; 1 sheet

08
Title: Fuel Oil (Tehran, Esfahan-Arak)
Source: National Iranian Oil Company
Notes: specification and test method, 1 sheet

09
Title: Location of Power Plant, Tabriz Power Plant
Notes: answers to survey by JICA Preparatory; stacks 4.5m diameter x 2; 7 sheets

10
Title: The Rates for Public Utilities in 1374 (1995-96); 4 sheets

11
Title: Map of Islamic Republic of Iran - 1/1,600,000
Source: Gita Shenassi, 1984

12
Title: Complete Map of Tehran

13

Title: Information on Caspian Sea;

14
Title: Map of Tabriz - 1/250,000

15
Title: Information Related to Water Quality, Water Source, Climate, National Parks
Source: ICES to Japan Embassy 6/17/96; 10 sheets
Notes: Available standards for the exhaust of the power plants SO_2= 2000ppm???

16
Title: General Policies, Strategies and Goals of the Second 5 Year Economic, Social and Cultural Development Plan of I. R. Iran (1995 - 1999)
Source: Plan and Budget Organization, 1996, pp119, original

17
Title: I.R. Iran Environmental Strategy Study
Source: World Bank, May 1995, pp98, copied

18
Title: I.R. Iran - Tehran Transport Emissions Reduction Project
Source: World Bank - Project Document, 10/1993, pp18, copied

19
Title: National Strategy for Environment and Sustainable Development
Source: World Bank - United Nations Development Programme, 7/1993,
Notes: Contents and introductions only; Economics, forests, range lands, fisheries, industry and mining, energy development, transport policies, human settlements, air quality and pollution control, water ditto, health, marine and coastal zone, biodiversity, refugees, education and public awareness

20
Title: Macro Qualitative Objectives, Overall Policies and Strategies Set in the Second Development Plan
Notes: The same contents with #16, different wordings, probably a draft of #16

21
Title: Law Concerning the 2nd Five Year Plan of Economic, Social and Cultural Development of I. R. Iran
Source: Official Gazette of I. R. Iran, Dec/29/1994

22
Author: Office of Deputy Minister for Energy Affairs, Department of Environment
Title: Environmental Studies Programme
Source: Ministry of Energy, 1996, original, policy mainly in Persian

23
Title: Electric Power in Iran - 1992, original

24
Title: ditto - 1993, original

25
Title: ditto - 1994-95, original
Source: Power Division, MOE, pp59

26
Title: Iran's Power Industry Projects under Construction, original
Notes: nothing for Tabriz and Esfahan

27
Title: Iran Center for Energy Studies
Source: ICES, Catalogue

28
Title: Tabriz Thermal Power plant - 2 x 387MW
Source: Karbassi, MOE, 1996,
Notes: pp18 copied, specifications with drawings

29
Title: Esfahan (Islam-Abad) Power Plant
Notes: pp15, skeleton drawings, less specifications

30
Title: Year Record - 1374
Source: Esfahan Power Generation Management Co.

31
Title: Weather Information
Source: Weather Bureau, pp6, #57 included

32
Title: Answer to Question No. 8-2-1 & 8-3-1 of JICA Preparatory Team
Source: ICES?, pp4
Notes: Population and public facilities in the Tabriz region, gas & oil elements

33
Title: Maps around Tabriz: 5166 II, 5266 III, 5266 II, 5165 I, 5265 IV, 5265 I
Notes: 6 maps, all 1/50,000

34
Title: Maps around Isfahan: 6255 II, 6355 III, 6254 I, 6354 IV
Notes: 4 maps, all 1/50,000

35
Title: A Plan for the Control of Air Pollution (Air Pollution Control Act)
Source: Department of Environment, Attachment to the report of the JICA Preparatory Team

41
Title: I. R. Iran - Economic Management and Prospects
Source: World Bank, Nov/1995, pp77, original

42
Title: Map of Tabriz NJ-38-B, 1/500,000
Source: Iranian Armed Forces

43
Title: Esfahan NI-39-C, 1/500,000
Source: Iranian Armed Forces

44
Title: Tehran NI-39-B, 1/500,000
Source: Iranian Armed Forces

45
Title: Guide Map of Azerbayjan-e-Sharqi-Gharbi & Ardabil Provinces, 1/600,000
Source: Gita Shenasi

46
Title: New Road Map of Esfahan Province, 1/670,000
Source: Gita Shenasi

47
Title: Map of Esfahan City, 1/12,700
Source: Gita Shenasi

48
Title: Complete Map of Tehran, 1/20,000
Source: Gita Shenasi

51
Author: MB Board of Editors
Title: Iran Yearbook '96
Source: Embassy of the Islamic Republic of Iran in Germany, Nov. 1995

52
Title: The Iranian Journal of International Affairs, Spring 1996
Source: The Institute for Political & International Studies, Tehran
Notes: p34-Oil at the Turn of the Twenty First Century, p220-Chronology

53
Title: ditto, Fall 1996
Source: ditto
Notes: p643-Middle East Natural Gas Pipeline Projects, p707-Chronology

54
Title: Chapter 13 - Air Quality and Pollution Control, National Strategy for Environment & Sustainable Development, Part IV: Pollution Abatement and Environmental Health
Source: UNDP, 1994; Details of a part of #19, copied, pp43
Notes: Monitored data by DOE and Health Division; Ambient standards?

55
Author: Eskandar Firouz
Title: Environment Iran
Source: The National Society for the Conservation of Natural Resources and Human Environment, 3/1974, pp54, original

56
Title: Fuel Oil Used in Tabriz Power Plant
Source: Tabriz Power Plant, 1 sheet
Notes: Analytical data of 5 samples Feb., June, August, Sept. 1994 and May 1995

57
Title: Temperature and Rainfall in Tabriz and Esfahan (1992)
Source: ICES, Monthly data, 1 sheet

61
Author: Environment Department, the World Bank
Title: Pollution Prevention and Abatement Handbook - Draft
Source: World Bank, September 1997

62
Author: U.S. EPA
Title: Compilation of Air Pollutant Emission Factors, Vol. I, Stationary Point and Area Sources
Source: 9/1985

63
Author: Kazuyasu Nemoto and Mitsuo Nishio
Title: Social Impact Assessment and Siting of Atomic and Thermal Power Plants
Source: Musashino Shobo (in Japanese)
Notes: A research and a case study on social impact assessment of power plants in Japan.

64
Author: Department of Environment, Ministry of Science, Technology and Environment, Malaysia
Title: A Handbook of Environmental Impact Assessment Guidelines
Source: First Edition, July 1987, Reprinted, May 1988
Notes: This handbook has a compact and systematic explanation of EIA. This book also includes a checklist of project activities for power generation and transmission.

65
Title: ditto
Source: Second Edition, August 1995
Notes: This is a revised edition of the handbook edited in July 1987.

66
Author: Department of Environment, Ministry of Science, Technology and Environment, Malaysia
Title: Environmental Impact Assessment Guidelines for Industrial Projects
Source: First Edition December 1995
Notes: This is to supplement for industrial projects of #65 (the Handbook of Environmental Impact Assessment Guidelines) by providing additional information on the procedural requirements as well as in post-EIA compliance work.

67
Author:
Title: Environmental Impact Assessment Proposed Extension Connaught Bridge Power Station, Klang, Selangor Darul Ehsan
Source: June 1991
Notes: An EIA report for gas turbine and combined cycle units in Malaysia.

68
Author: U.S. EPA
Title: Environmental Impact Assessment Guidelines for New Source Fossil Fueled Steam Electric Generating Stations
Source: PB 299479, July 1979
Notes: The guidelines are intended to assist in the identification of potential impacts, and the information requirements for evaluating such impacts, in EIA.

69
Author: U.S. Department of the Interior
Title: Guidelines for the Preparation of Environmental Reports for Fossil-Fueled Steam Electric Generating Stations
Source: PB-266 071, Nov 1976
Notes: These guidelines describe many types of information which should be assembled into an Environmental Report (ER) by an Applicant who proposes to construct a fossil-fueled electric generating unit and who requires a grant, license, permit or approval from the Federal Agency. The resulting ER would serve as the Applicant's input from which the Federal Agency would prepare an Environmental Impact Statement (EIS).

70
Author: John V. Winter and David A. Conner
Title: Power Plant Siting
Source: Van Nostrand Reinhold Environmental Engineering Series, 1978
Notes: This book attempts to break down and describe the complexities of the siting process. It includes Siting scenarios (chapter 4) and environmental considerations (chapter 5).

71
Author: Agency of Resources and Energy
Title: A New Handbook for Thermal Power Plants (in Japanese)
Source: 1985
Notes: This book describes fossil fuels, electric generating facilities, construction, operation and maintenance of a thermal power station, siting and environmental conservation.

72
Author: Editorial Committee for Lectures on Electric Power Supply Industry
Title: Lecture No.14 Electric Power Supply Industry and Environment (in Japanese)
Source: 1996
Notes: This book describes environmental problems which the electricity supply industry faces and with which how they are coping.

73
Author: Jack Golden, et al.
Title: Environmental Data Book
Source: Ann Arbor Science
Notes: Cooling tower plume models (p159 ~169) and modeling of water thermal discharge (p214~ p227)

74
Author:
Title: Environmental Impact Analysis Handbook
Source: McGraw-Hill
Notes: Air quality impact analysis - power plant case study (p3-139 ~ p3-161) and noise impact analysis (p4-1 ~ p4-49)

75
Author: U.S. EPA
Title: Environmental Assessment of an Oil-fired Controlled Utility Boiler
Source: PB80-190085
Notes: The report gives a comprehensive emissions assessment of the Haynes No.5 boiler during oil-firing.

76
Author: U.S. EPA

Title: Environmental Assessment of a Coal-fired Controlled Utility Boiler
Source: Apr 80, PB80-187735
Notes: Contents, Sections 1 only. The report gives results of comprehensive multimedia emissions assessment of the cyclone-fired La Cygne No. 1 boiler, equipped with SO2 and particulate emission controls.

77
Author:
Title: Industrial Pollution Control - General Review and Practice in Japan- Volume 1 Air and Water
Source: Industrial Pollution Control Association of Japan, 1981
Notes: A kind of a text book for air pollution and water pollution. It covers pollution sources, behaviors of pollutants, simulation, regulations, influences, pollution control technology, and measurement.

78
Author:
Title: Industrial Pollution Control - General Review and Practice in Japan- Volume 2 Noise and Vibration
Source: Industrial Pollution Control Association of Japan, 1982
Notes: A text book for noise and vibration. It covers pollution problems, fundamentals, sources, effects, regulations, control technology, and measurement.

79
Author: Environmental Law and Institutions Programme Activity Centre
Title: Handbook of Environmental Law
Source: United Nations Environmental Programme, year unknown (1994?)
Notes: Various international treaties and agreements, pp453

80
Author: Environmental Law Guidelines and Principles: Series-9
Title: Environmental Impact Assessment
Source: UNEP, 6/17/1987
Notes: 3 goals of EIA and 13 principles to do EIA, pp4

81
Author: Japan Weather Association and UNICO International Corporation
Title: The Study on an Integrated Master Plan for Air Pollution Control in The Greater Tehran Area in The Islamic Republic of Iran - Final Report
Source: JICA, 12/1997

82
Author: GEMS Monitoring & Assessment Research Centre, London
Title: Environmental Data Report, 1993 - 1994
Source: UNEP,
Notes: Country wise study on various environmental conditions

83
Author: The Institute of Energy Economics, Japan
Title: I. R. Iran, Comprehensive Energy Studies - Final Report
Source: JICA , March 1994

84
Title: T.R.E.C - Tehran Regional Electricity Co. 1994-1995
Source: TREC

Notes: Catalogue including a future plan: no mention on the environmental issue

85
Title: General Data of Iran Power Plants
Source: Amar Tafzily (1995), MOE, Deputy for Electric Affair, Office of Electric Planning
Notes: Lists of plants, and characteristics and a figure of high voltage network

86
Author: Japan National Astronomical Observatory, Editor
Title: Rika Nenpyou (Chronological Scientific Tables, in Japanese)
Source: Published by Maruzen, Nov/1994

87
Title: NOx Manual (in Japanese)
Source: Japan Environment Agency 1995

88
Title: Iranian EIA Guidelines (Draft)
Source: Translated into English by a private expert for the JICA Team
Notes: Main parts only

89
Author: Hachiro Yamamoto
Title: Hearing Memo at Tabriz, March/1998
Notes: One year power generation, fuel and water consumption, etc.

90
Author: Air Pollution Studies Office
Title: Environmental Criterias and Standards (Human Environment Affairs)
Source: Deputy for Human Environment Affairs, Department of the Environment, 1998
Notes: translated by MOE and AQCC, pp24

91
Title: The Iranian Journal of International Affairs, Spring 1997
Source: The Institute for Political & International Studies, Tehran
Notes: p111-International Gas Conference(Feb/1997) - 25×10^{12} m^3 gas reserve, p137-Chronology

92
Title: The Iranian Journal of International Affairs, Summer 1997
Source: The Institute for Political & International Studies, Tehran
Notes: p324-Chronology

93
Title: The Iranian Journal of International Affairs, Fall 1997
Source: The Institute for Political & International Studies, Tehran
Notes: p488-Chronology

94
Title: The Iranian Journal of International Affairs, Winter 1997/1998
Source: The Institute for Political & International Studies, Tehran
Notes: p632-Chronology

95
Author: US-EPA

Title: Compilation of Air Pollution Emission Factors (AP-42) 5th Edition, Vol. 1 Chapt. 1, Article 1.3 Fuel Oil Combustion
Source: http://www.epa.gov/ttn/chief/ap42etc.html, Oct/21/98 retrieved, file:c01s03.pdf

96
Author: ditto
Title: ditto, Article 1.4 Natural Gas Combustion
Source: ditto, file:c01s04.pdf
Notes: NOx (as NO_2) emission at large uncontrolled wall-fired boilers - 190 to 280 lb/10^6 scf of natural gas burnt (1,020 MMBtu/10^6scf)

97
Title: The Iranian Journal of International Affairs, Spring/Summer 1998
Source: The Institute for Political & International Studies, Tehran
Notes: p164-Chronology

98
Title: Electric Power Industry in Iran - 1997/1998
Source: Power Division, MOE

99
Author: News Papers: Iran News, Kayhan International, Tehran Times, Tehran News
Source: Various clips
Notes: Cited as (#99, 2/8/98) in the Report for example. Numerals are month/day/year of the paper published.

100
Title: Iran, Islamic Rep. At a glance 9/18/98
Source: World Bank, Development Data: Country Data: Web site - worldbank.org/cgi-bin/sendoff.cgi?page=%2Fdata%2Fcountrydata%2Firn_aag.pdf

101
Author: Public Relation and International Bureau of Tavanir
Title: Power News (Monthly Magazine)
Notes: Published date is unknown. However later than November 1998

102
Author: Public Relation and International Bureau of Tavanir
Title: Power News (Monthly Magazine), February 1999

103
Author: MATN International Co.
Title: MATN NEWS, December 1997

104
Author: Public Relation & International Bureau of MOE
Title: NIROO Message, November 1998

105
Author: Public Relation & International Bureau of MOE
Title: NIROO Message, December 1998

106
Author: Public Relation & International Bureau of MOE
Title: NIROO Message, January 1999

107
Title: World Development Indicators 1998
Source: World Bank
Notes: Table 3.12 Air Pollution in 1995

108
Author: TRW, Inc
Title: Environmental Assessment of an Oil-fired Controlled Utility Boiler
Source: US-EPA, PB80-190085, EPA-600/7-80-087

109
Title: SPM Manual (in Japanese)
Source: Japan Environmental Agency, December 1997

110
Title: Study on Emission Factors of Stationary Sources (in Japanese)
Source: Japan Environmental Agency, July 1976

111
Title: Air Quality Prediction Manual (in Japanese)
Source: Industrial Pollution Control Association (Japan), March 1985

Author:
Title:
Source:
Notes:

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