PUBLIC ESTABLISHMENT
FOR ELECTRICITY GENERATION
AND TRANSMISSION
SYRIAN ARAB REPUBLIC

No. 1

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR REHABILITATION OF
BANIAS POWER STATION
IN
SYRIAN ARAB REPUBLIC

MARCH 1999

JAPAN INTERNATIONAL COOPERATION AGENCY

EPDC INTERNATIONAL LIMITED

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PREFACE

In response to a request from the Government of Syrian Arab Republic the Government of Japan decided to conduct a basic design study on the rehabilitation project for improvement of the Banias Power Station and entrusted the study to the Japan International Cooperation Agency (JICA).

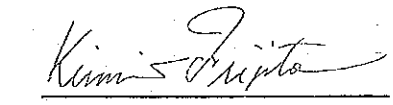
JICA sent to Syria a study team from October 23, 1998 to November 20, 1998.

The team held discussions with the officials concerned of the Government of Syria, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Syria in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Syrian Arab Republic for their close cooperation extended to the teams.

March, 1999



Kimio Fujita
President
Japan International Cooperation Agency

March, 1999

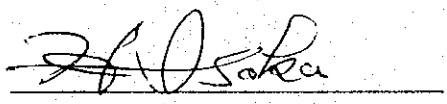
Letter of Transmittal

We are pleased to submit to you the basic design study report on the rehabilitation project for improvement of the Banias Power Station in Syrian Arab Republic.

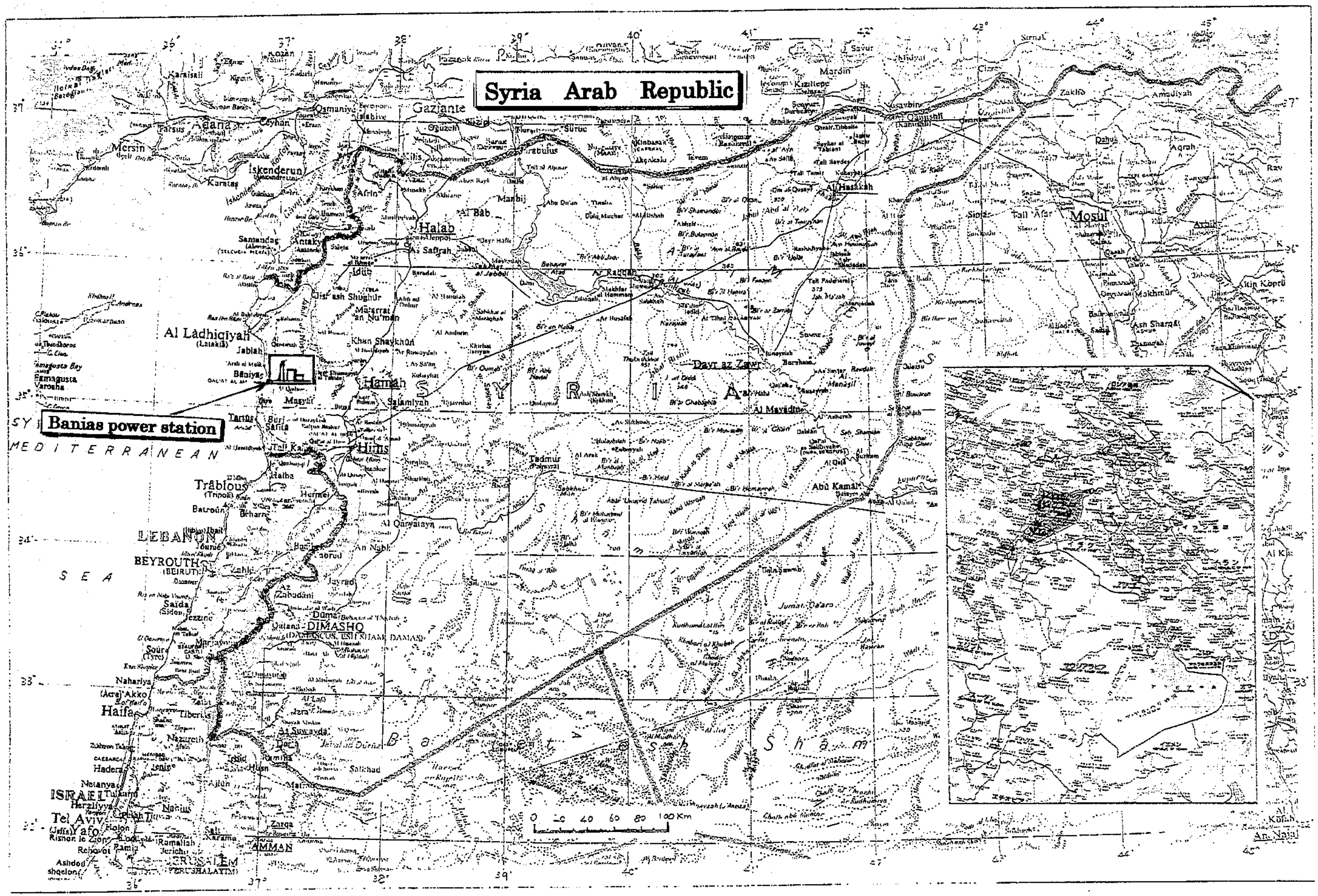
This study was conducted by EPDC International LTD. under a contract to JICA, during the period from October 9,1998 to March 31,1999. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Syria and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Hiroshi Isaka
Project manager,
Basic design study team on
the rehabilitation project
for improvement of
the Banias Power Station
EPDC International LTD.


Syria Arab Republic
Banias power station
Al Ladhiqiyah
Halab
Hamah
Hims
Dayr az Zawr
Tadmur
Abu Kamal
Al Hasakah
Mosul
DIMASHQ
Trablous
BEYROUTH
LEBANON
Haifa
Tel Aviv
ISRAEL
AMMAN
JERUSALEM
Gaziante
Adana
Mersin
Iskenderun
MEDITERRANEAN
SEA
0 20 40 60 80 100 Km

Abbreviations

PEE	:	Public Establishment of Electricity
PEEGT	:	Public Establishment for Electricity Generation and Transmission
PEDEEE	:	Public Establishment for Distribution and Exploitation of Electric Energy
MOE	:	Ministry of Electricity
UNDP	:	United Nation Development Plan
SPC	:	State Planning Commission
FOR	:	Forced Outage Ratio

CONTENTS

[Appendices]

Chapter 1 Background of the Project

Chapter 1 Background of the project

In Syrian Arab Republic, the population of the nation is one thousand and five million. Educational and technical level are generally high level. Major industry is oil and gas, and the economical structure is generally well balanced. It is considered to be high latent potential on the agriculture, industry, commerce, and tourism.

On the other hand, the first priority concerned for the Japanese government's aid is given to the agricultural development, and the second one is given to the industrial development of oil and natural gas and the level-up for the national life for the part of support on the peace process for the middle east.

As for the electric power balance, the electric demand had exceeded its supply from 1970', and Syrian Arab Republic had consistently made the effort to increase electric supply in Fifth Five Year Development Plan starting from 1981. In 1986, the Banias Power Station Extension Project (twenty six billion and seven million Japanese yen) was executed as the first Japanese loan aid project in Syria. The Banias Power Station has put in service in 1989 and covered 30% of the whole electric demand in Syria.

Presently, Tishren Hydraulic Power Station (capacity 600MW) and the Jandar Combined Power Station (capacity 600MW) have completed in 1997 and 1998, and these power stations are positioned as the base load power stations in 6,190MW of total electric supply capacity in Syria. On the other hand, Banias Power Station is positioned to serve the power for middle load. It is confirmed that Banias Power Station is considered as the important power supply sources to maintain the stability of the western Syrian power grid from now on.

In the present situation of the Banias Power Station, there is no major problem in the daily operation, and it was originally considered that major overhaul should be executed every four years which had never carried out. Only the minor overhaul for simple equipment except the main turbine and the generator had been executed. Therefore, the necessity for the execution of the major overhaul is recognized due to the following issues;

(a) Frequency of the unit shutdown has been once a month

(b) Unit is being operated by the negligence of maintenance of the mal-actuating equipment

(c) Unit is being operated without understanding the situation of damages, fatigues and deterioration of equipments

(d) Unit is being operated with the deteriorative plant performance

(c) Light blackish flue gas is observed due to the mal-combustion

Under the above mentioned circumstances, the supply and demand balance is not tight at present due to that new power development has been executed after Banias Power Station Extension Project. There might be again a shortage of electricity after 2004 if no new power development plans is executed. Therefore it is recommended to execute the major overhaul of No.3 and No.4 units under the present condition having more than 20% of the allowance of power generation in Syria and during the light load period in Banias Power Station. Since Banias Power Station has not conducted the major overhaul due to the limitation of the budget and lack of technology for it, Syrian government has requested the implementation of the overhaul including the procurement of the spare parts and the continuous gas monitering apparatus for flue gas as a countermeasure for the environment were requested to be covered in the Japanese Grant Project to Japanese government.

According to this request, the Japanese Government decided to execute the basic design study, and Japan International Cooperation Agency (JICA) dispatched a study team to Syria from 23 October 1998 to 20 November.

The team has identified the request from Syria, the general concept on the overhaul implementation of Syria, the power supply and demand balance status of Syria, the actual operating status of the Banias Power Station, the capability of the organization executing overhaul in the power station. After return back to Japan, the team made the analysis and basic design. The result was summarized for the draft basic design study report. The team explained the draft report to Syria for the basic design report from 21 February 1999 to 3 March 1999.

Chapter 2 Contents of the Project

Chapter 2 Content of the Project

2.1 Objectives of the Project

The object of this project is to execute the major overhaul for Banias No3and No4 units in order to replace the damaged or deteriorated parts, to verify the soundness of the system, to improve the bad conditions and to recover the reliability of the equipment and plant performance.

The Japanese supervisors shall be dispatched for technical advice of the major overhaul at minimum period , and Syrian side shall take the responsibility for the overhaul work itself.

2.2 Target of Restoration of Reliability and Recover of Plant Efficiency

The target of restoration of reliability and recovery of plant efficiency will be achieved , if periodical overhaul is certainly implemented by Syrian side after completion of this project.

(1) Restoration of reliability of power station

(a) Status of Power Station

Unit shutdown which declines the reliability of the power station took place 30 times during recent 4 years (1995~1998), and the details are that the troubles took place 8 times (28%) at steam turbine condensers, 6 times (20%) at boilers ,6 times (20%) at controllers, 3 times (10%) by system fluctuations, 3 times (10%) by thunderbolts, 2 times (6%) at boiler auxiliaries, 1 time (3%) at turbine auxiliary and 1 time (3%) at electric device.

On the other hand, according to the detailed study on Forced Outage Ratio (FOR[*1]) which is one of parameters showing plant reliability. FOR(s) of No.3 and No. 4 units from January to November of 1998 were 4.4% and 4.6% as high figures, respectively. (Approximately, 1% in Japan, 5% in USA)

The principal reasons for these figures are the burner damage troubles at No. 3 unit and the steam leakage troubles from pressure parts of boiler at No.4 unit.

And, the averaged Availability Factors[*2] from 1989 (year of initial start-up) to 1997 were 89% at No.3 unit and 92% at No. 4 unit, and 86% and 70% in

1998, respectively. And the annual Availability Factor shows the lowering tendency.

*1 FOR = (Forced Outage Hour)/(Forced Outage Hour + Service Hour) x 100
*2 Availability Factor = (Service Hour)/(Period Hour) x 100

(b) Target of Reliability

Under the above-mentioned situation, FOR and Availability Factor seems to be 1.5% and 90% respectively after completion of this major overhaul, as the target to recover the reliability of the power station. For the purpose to recover the reliability, the spare parts will be selected and also the major overhaul will be executed.

However, the following facts will be considered.

① In Major Overhaul, the confirmation of soundness on all of parts of the power generation facilities will be physically impossible due to the limited period and budget.

② The total operating hours of No.3 and No. 4 units will exceed 100,000 hours of boiler tube design life at the middle of 2000, therefore the boiler tube failure troubles will happen more frequently.

③ Other troubles will happen with the equipment which will be excluded from the major overhaul.

It is expected that the value of FOR will be lower after the completion of Major Overhaul, but troubles will take place at the different parts due to the reason ①, ② and ③.

If the overhaul is implemented yearly by Syrian side after the completion of Major Overhaul, it is predicted to maintain FOR at 1.5% and Availability Factor at approx. 90%, and the numbers of trouble will decrease due to periodical execution of overhaul at every year.

In case, any overhaul is not implemented, FOR will surely increase more than the present value as aforementioned.

(2) Improvement of Plant Efficiency and Preservation of Environment

According to the boiler performances measured at 150 MW and 60 MW operations, although the conclusion may have some estimation error due to the lack of reliability of instrument accuracy, the efficiency may decrease by 10% in comparison with that measured at the commissioning.

The efficiency decrease may be caused by the poor factors such as the decline of thermal efficiency of boiler due to the fouling of boiler tube surface, the lack of exchanging heat at air heater due to the deterioration of elements, the increase of bypass air of FDF, the decline of combustion efficiency, the increase of heat losses due to steam and water drain leakage.

Although the decline of plant efficiency due to aging can not be avoided, the target of this project will be that the plant efficiency is recovered to 97～98% of initial value at commencement of plant operation. Namely, about 36% will be obtained by executing the exchanges of damaged parts and the adjustments of the related equipment in comparison with 33% efficiency of 1998.

If the plant efficiency is improved from 33% to 36%, the fuel consumption results in 8% of reduction. Accordingly, as volumes of pollutants , SOx, NOx and dust, will be reduced proportionally, the ground concentrations of those pollutants will be also reduced at residential area.

2.3 Basic Concept of the Project

2.3.1 Review on Adequacy of Request

The request is composed from ① Plan on Major Overhaul, ② Procurement Plan of Parts required for Major Overhaul and ③ Measures for Flue Gas Pollution.

(1) Implementation Plan of Major Overhaul

(a) Implementation of Major Overhaul

According to the maintenance report, the damages took place at boiler tube, burner, air heater, turbine condenser, controller, etc., and unit shutdown took place once a month in 1998. These troubles can be prevented by implementation of periodical overhaul.

Accordingly, it is judged to be adequate that the implementation of Major Overhaul shall be made as planned by this report to prevent unit shutdown and to maintain the stable electric supply.

(b) Dispatch of Supervises for Overhaul

Banias power station has the experience to call the supervisors from the supplier of steam turbines at No.1 and No. 2 units, when steam turbine was damaged.

And, as aforementioned, at Banias Power Station, the extents of knowledge, technology and experience on major overhaul are limited from view point of maintenance method. Accordingly, as it is very difficult to implement major overhaul by Syrian people themselves, the proposed plan to dispatch Japanese supervisors for technical advice is considered to be reasonable.

(c) Technology Transfer through OJT

Overhaul is important task to maintain the soundness of power station, and requires rich experiences, rich knowledge and high level capabilities of technology and management.

In order to implement the major overhaul by Syrian people themselves at Banias Power Station and other similar stations in future, it is considered that the technology transfer through OJT is essential.

(2) Procurement of Parts required for Major Overhaul

By this survey result, the parts required for major overhaul, which will be procured by Japanese side, are summarized by classifying into mechanical, electrical and instrumental.

Among the parts concerned, the parts stored in the power station will be used with priority, but insufficient parts and newly required parts which can not be procured in Syria, and it is judged to be adequate that these parts shall be procured by Japanese side by considering financial situation of Syria.

(3) Measures for Flue Gas Pollution Control

(a) Procurement of Flue Gas Monitoring TV

By this survey result, the light blackish flue gas was observed and it is worried that air pollution at town area when wind is directed to the town. In order to maintain good firing condition and to regulate emissions of pollutants, it is important to monitor the flue gas situation and to operate the boilers properly. At Al-Zara and Aleppo power stations, it is planned to install flue gas monitoring TVs.

From the above reason, it is judged that procurement of flue gas monitoring TV is reasonable.

(b) Procurement of Continuous Flue gas Monitoring Apparatus

① By the survey result made at Ministry of Environment of Syria, although the draft of air pollution regulation law was established in 1994, the standards on emissions from power station and others are

not stipulated in the regulation.

At present, the regulation is still let as the draft, and there is no movement in which air pollution regulation including emission standards comes into effective in the near future.

Accordingly, there is no legal background to install the continuous flue gas monitoring apparatus.

② SO_2 and NOx monitoring apparatuses are planned to install as flue gas monitoring apparatuses at Al-Zara power station (200 MW×3 sets, dual firing with heavy oil and natural gas), which is scheduled to be completed in 1998～2000.

On the other hand, at Aleppo power station (200 MW×4 sets, dual firing with heavy oil and natural gas), which is scheduled to be completed in 1998, the monitoring apparatuses are not installed. PEEGT of Syria has no the obvious legal background to request installation of monitoring apparatuses.

③ Syrian government is promoting the projects to make fuel conversion from heavy oil to natural gas, and at Banias Power Station fuel will be converted from heavy oil to natural gas in the near future.

In case of natural gas firing, due to that generation of SO_2 and dust will nearly reduce to zero , it is meaningless that monitoring is made by installation of continuous gas monitoring apparatuses.

From the above view points, it is considered to be inadequate to procure continuous flue gas monitoring apparatuses.

(4) Natural Gas Fuel Conversion Project

At this survey, it was explained by Syrian side that Fuel Conversion Project (heavy oil is converted to natural gas) is being planned in Banias power plant. If fuel is converted to natural gas, the revamping as shown in Table2-1 will be carried out, which does not overlap with all items of this project including parts supply.

Table 2-1 Fuel Conversion Project

Fuel Conversion Project	Relation to this Project
Partial revamping of boiler tube	Boiler tubes will be used for replacement of damaged parts in this major overhaul, accordingly, revamping of boiler tube is not affect to the fuel conversion project.
Addition of gas firing equipment and system	No relation to this Project because gas firing equipment is installed additionally to the existing oil burning system.
Addition of gas supply equipment and system	No relation to this Project because gas supply equipment is installed additionally to the existing oil supply system.
Addition of control system for gas firing system	No relation to this Project because gas firing control system is installed additionally to the existing oil burning control system.

As adequacy of the request is confirmed excluding the continuous flue gas monitoring apparatuses from the above-mentioned reviews, the detailed reviews on the project are made in the following paragraphs.

2.3.2 Basic Concept of the Project Implementation

(1) Implementation Plan of Major Overhaul

Implementation scheme, schedule and period of major overhaul and dispatch schedule of supervisor were decided by executing the detailed studies of actual condition of Banias Power Station and by considering Syrian side intention.

(2) Procurement of parts required for Major Overhaul

It is important to select properly and replace the equipment and parts at major overhaul, the followings are the evaluation criteria and procedure.

(a) Selection criteria

① Equipment and parts relating to relapse of unit shutdown

② Equipment and parts relating to unit shutdown due to deterioration

③ Damaged parts giving obstacles to maintaining plant performance

④ Damaged parts giving obstacles to maintaining plant safety

(b) Selection procedure

① Making selection table for equipment and parts based on procurement plan

② Classification of equipment and parts by ranking importance priority in order of A, B,.C.

③ Deciding the specification (dimension, material, grade, quantity, weight etc.) having priority A.

④ Confirmation of the parts which stored in the Banias Power Station.

⑤ Selection of equipment or parts to be compatible with the existing ones which have been obsolete in manufacturing.

(3) Abatement of Flue Gas Pollution

By this survey result, the light blackish flue gas was observed and it is worried that air pollution at town area when wind is directed to the town. In order to avoid pollution, it is decided to procure the flue gas monitoring TV, with which the pollutant by monitoring the flue gas condition and operating the boilers properly.

As a original request, the flue gas monitoring apparatus was listed up for the environmental countermeasure, but it was considered to be inadequate to procure continuous flue gas monitoring apparatuses (analyzer) by the result of basic design study.

From the above study results, the basic concept of the project is to execute the major overhaul, to procure the equipment and parts for Banias No.3 and No.4 units in order to recover the reliability of the systems, plant efficiency and to maintain the stable electricity supply, and to procure the flue gas monitoring TV for air pollution control. The summary of basic design is shown in Table 2-2, 2-3 and 2-4.

Table2-2 Basic Design (Major Overhaul Implementation Plan)

Classification		Content	
① Scope of Project		Major Overhaul*	
② Schedule		3 unit & 4unit	
③ Period		100 days per unit	
④ Engineer	No.3 Unit	Total 23 men	Total 27.94M/M
	No.4 Unit	Total 10men	Total 17.24M/M

*Overhaul Guideline for Thermal Power Station : Thermal and Nuclear Power Engineering Society

Table2-3 Basic Design (Parts Procurement Plan for Major Overhaul)

Classification	Content
① Boiler & Auxiliaries	Boiler tube 140pcs
	Bearings, packings for draft fans
	Burner parts
	Elements, fittings for air heater
	Parts for soot blower
	Parts for flue duct
	Parts for safety valves
	Parts for water gage
	Packing for high pressure valve
	Parts for fuel system
	Parts for chemical dosing, sampling system
	Parts for common facility
② Turbine & Auxiliaries	Parts for high/low pressure turbine
	Parts for HP pedestal, bearing etc.
	Parts for main valve
	Parts for control oil system
	Parts for lubricating oil system
	Parts for high pressure heater
	Parts for feed water pump
③ Electric & Control System	Parts for recorders in control room
	Parts for detecting device
	Parts for control valve and drive
	Parts for switches for control panel
	Parts for pressure switches for compressor
	Parts for I/P signal protection system

Table2-4 Basic Design (Air Pollution Control Plan)

Classification	Content
Flue Gas Monitoring TV	Color CCD camera
	Color monitoring TV

2.4 Basic Design

2.4.1 Design Concept

(1) Natural conditions

(a) According to the climatic data during 21 years from 1956 to 1977 in Banias, the highest temperature, 38.6°C, was recorded in August, and the lowest monthly mean temperature was 10.3°C. Average mean temperature was 19.5°C, it's very mild weather from these data.

Rainy season is from December to April, and dry season is from May to November. The annual rainfall is 943 mm.

The design ambient temperatures are determined at 40°C as the highest and at -10°C as the lowest.

(b) Studying from the statistics of natural condition, it is not required to take earthquakes or typhoons into account the design, and on the installation of the equipment and materials, because of no exceptional condition.

(2) Social conditions

Generally, the public security is kept pretty well in Syria and also the political stability is kept pretty well.

As Syria has hostile relation with Israel, the public security is being kept well through the country including Banias area.

(3) Procurement situation and source

(a) Past situation on procurement of spare parts in Banias Power Station

Spare parts for the Banias Power Station have been procured principally from original manufacturers, but only condenser tubes have been purchased from Europe.

In this project, all spare parts will be procured from Japan.

(b) Procurement source

According to the study, the parts required for major overhaul will be procured from Japan, because there is the difficulty to make its procurement in Syria and from third country in a short period.

It will be decided to make the procurement of equipment and parts from the manufacturers who have constructed No. 3 and No. 4 units and can have the responsibility of design for the whole system of the power plant.

(4) Adoption of local contractor

According to the study, Banias Power Station will not adopt local contractor because the power station has enough man power to maintain the all systems from No1 unit to No4 units.

There are no special maintenance contractor or firms near the power station. Even if it is possible to call contractor from far area, the power station does not have any accommodation or transportation means. Therefore local contractor seems to be not adopted in this project.

(5) Inventory management of Spare Parts

(a) Procured spare parts are managed by the Banias Power Station, or spare parts kept in the store are managed by the store section.

(b) The store house is divided by each kind of spare parts, and small spare parts are stored on a rack. Storing situation is partially disordered, but tolerable.

Delivery and receiving of spare parts are managed item by item with mean of slip.

A inventory in the store house is made every year end.

(c) Even though it is considered that the power station has the inventory management capability of spare parts, the inventory control specialist shall be dispatched to Banias Power Station, because the numbers of spare parts procured for this project will reach approximately 15,000 pieces that may exceed the routine inventory management capability of the power station.

2.4.2 Basic Plan

(1) Whole plan

Following are the condition of this project.

The concerned infrastructure for the implementation seems to be preferable as described hereinafter;.

(a) Location of the Banias power station

Banias Power Station is located near the Banias city where is 220km north-northwest of the capital city of Damascus. Banias city is located in north latitude 35° and east longitude 36°, and 40km south of tourist city of Latakia.

Principal industries of Banias city are agriculture, oil refinery and power station.

(b) Condition of unloading port

Latakia port is a main port of Syria and its facility is substantial. The materials for the project will be unloaded at the Latakia port.

(c) Transportation of equipment and materials

The equipment and materials, which transported from Japan to Syrian harbors by ship, will be transported to Banias power station site by truck through the highway.

(d) Same quality of equipment and spare parts

The same specification shall be applied.

(e) Applicable code and regulation

The following Japanese codes and regulations will be applied, or equivalent international codes and regulations are available for the design.

Japanese Industrial Standard (JIS) is mainly applied for a materials, and others are Japan Electric Committee (JEC), Japan Electric Manufacturer's Association(JEM), Japan Electrical Engineering Association(JEAC), Japan Cable Standard (JCS) International Standardization Organization(ISO), British Standard(BS), German Industrial Standards(DIN), American Society of Mechanical Engineers(ASME)

2.4.3 Basic Design

By the detail of this project described in the above paragraphs, this project is composed from ①Plan on Major Overhaul, ②Procurement Plan of Spare Parts required for Major Overhaul and ③Abatement Plan of Flue Gas Pollution.

To these requests, the most suitable proposals planned by this survey result are as follows;

(1) Plan on Major Overhaul

(a) Execution Scope of Major Overhaul

According to the Periodical Overhaul Guideline for Thermal Power Plant edited by Thermal and Nuclear Power Engineering Society in Japan, there are [A] Overhaul (Major) which is periodical and precious one, [B] Overhaul (Ordinary) which is periodical and normal one and [C] Overhaul

(Simple) which is minor one. The cycle of overhaul is shown in Table 2-5.

Table2-5 Cycle of Overhaul

Year	1	2	3	4	5	6	7	8
Turbine	A	C	B	C	A	C	B	C
Boiler	A	B	A	B	A	B	A	B

A: Major Overhaul B: Overhaul C: Simple Overhaul

As aforementioned, at the power station concerned, the overhaul, inspection and repair works are being implemented only when damages took place. The planned and systematic overhaul has not being implemented for the main equipment and parts in Banias Power Station.

According to review on the maintenance history and the survey results, it is judged [A] Overhaul (Major) will be the most applicable.

The detail of execution scope of overhaul (equipment and parts to be overhauled, detail of overhaul schedule, method of overhaul, etc.) are based on the following documents in Appendices (Data 6-1);

- Boiler and its accessory
  BOILER PLANT RECOMMENDED OVERHAUL INSPECTION WORKS
- Steam Turbine and its accessory
  TURBINE RECOMMENDED OVERHAUL INSPECTION WORKS

(b) Time to implement Major Overhaul

By the this survey result, it is predicted that the allowance of power generation in Syria will become more than 20% as shown Fig.2-1 according to the completions of No.5 & No.6 units (100 MW each) at Tishren hydraulic power station in 1998 and No. 4 & No. 5 units (200 MW each) at Aleppo thermal power station in 1998, and No. 1 – 3 units (200 MW x 3 units) at Al-Zara thermal power station in 1999.

On the other hand, according to PEEGT's power generation plan for Banias Power Station during 1998 to 2010, the power generation in 2010 is expected to increase by 30% in comparison with those during 1998 to 2000. Accordingly, it is judged to be implemented in early year that the overhaul for No.3 and No.4 units shall be implemented in 2000 as planned, since the

allowance of power generation in the earlier opportunity is bigger than that in the later.

And, PEEGT has no objection to this planned implementation time of major overhaul, and to take procedure to shutdown the power station concerned.

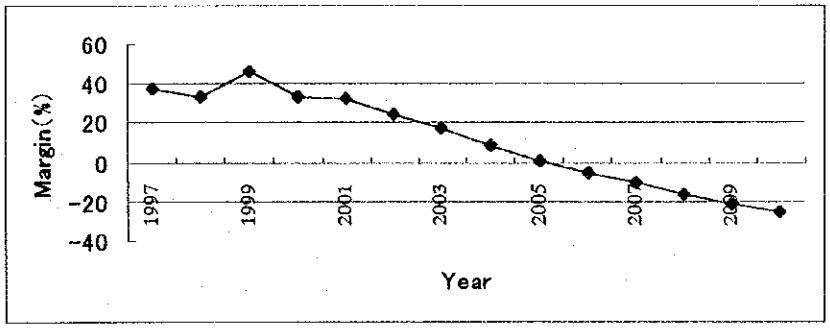


Fig.2-1 Reserve Margin

(c) Period to implement the major overhaul

① Turbine and its accessory

Banias Power Station has the experience of the implementation of the overhaul for No.1 and No.2 turbine at three times in order to repair the damages occurred by troubles, which were executed without any personnel assistance from outside of power station and under the assistance of the supplier of the turbine, and the power station has the excellent stuffs including skilled crane operator.

By considering the experience in No.1 and No.2 units, it is scheduled that the overhaul for No.3 and No.4 units can be completed in 85 days as initially planned, but 100 days is decided by considering the unforeseen situation. The detail schedule is shown in Appendices (Data 6-2); Major Overhaul / Inspection Time Schedule.

② Boiler and its accessory

Banias Power Station has the experience to implement the repair and exchange work for wall tube of boiler furnace and steam superheater tube at No.1 and No.2 units, and has the experience to install scaffold by using steel pipe like Japanese one.

Accordingly, as Banias Power Station has the experience regarding the overhaul of pressure part of boiler, it is judged that the overhaul of boiler and its auxiliaries can be implemented as planned schedule.

But, regarding air heater, in addition to the overhaul inspection, planned schedule (40 days) is to be extended. Since the removal

work of damaged elements, the installation work of new elements, adjustment work, etc. will be executed parallel at A and B airheater.
By the experience of repair work for the air heater executed from February to April of 1998, it is judged that 60 days is reasonable for the overhaul period for air heater, but this extension period will not give influence on overall schedule.
The detail schedule is shown in Appendices (Data 6-2).

(d) Shut down Schedule for Major Overhaul

The basic design study team explained the necessity of about 100 days shut down of each plant (units No.3 and No.4) to implement major overhaul and proceed the Project under Japan's grand aid system. The Syria side agreed to the explanation.

(e) Dispatch Plan of Supervisors

By the experiences of repair works implemented at No.1～No.4 units in Banias Power Station and the survey result on the units and also by taking into account the intention of the power station, it is judged to be reasonable that the following dispatch plan of supervisors including inventory control specialist is established by changing a part of the initial plan.

Items to be supervised; No.3 unit;

- Boiler and its auxiliary

  Boiler (general), safety valve, boiler auxiliary, fan, air heater, high pressure valve, boiler control, burner control, boiler start-up, diesel generator, air compressor, fire fighting ,deminerized water treatment.

  Required man-month; 14 personnel, 14.49 man・month

- Turbine and its accessory

  Turbine (general), turbine accessory, feed water pump, turbine start-up, generator, exciter, transformer, thunder protection

  Required man-month; 8 personnel, 12.15 man・month

  Total 22 personnel, 26.64 man・month

Items to be supervised; No.4 unit;

- Boiler and its auxiliary

  Boiler (general), boiler control , boiler start-up,

  Required man-month; 3 personnel, 5.9 man・month

- Turbine and its accessory

  Turbine (general), turbine accessory, feed water pump, turbine start-up, generator, exciter

  Required man-month; 6 personnel, 10.04 man・month

  Total 9 personnel, 15.94 man・month

Items to be supervised; Spare parts inventory control

No.3,4 unit spare parts inventory control

Required man-month; 1 personnel, 2.47 man・month
(only No.3 major overhaul)

And, as described in the previous paragraph, by considering the overhaul period for turbine is 100 days, the dispatch period of two supervisors for boiler and turbine is fixed at 100 days each as maximum.

And also, the number of supervisors at No.4 unit is decided to be reduced mainly at the boiler section by reflecting the effect of technology transfer made at the implementation of overhaul at No. 3 units.

The detail schedule is shown in Appendices (Data 6-3); SUPERVISER SCHEDULE FOR UNIT NO.3, SUPERVISER SCHEDULE FOR UNIT NO.4.

(f) Plan of Technology Transfer for Overhaul

Although the technology transfer will made through the joint implementation of overhaul with Syrian side, the experts dispatched from Japan shall be selected from the view points from both technical capability and leadership so as to achieve an objective that Syrian side will be able to execute overhaul by themselves.

And, as specific method, it will be given the careful consideration that "Technology Transfer Manual" composed from the following items will be made and its fruitful result will be certainly achieved.

① Planning of Implementation Plan

In order to understand the planning method, the planning process will be described for the implementation plan of the overhaul executed by this project.

② Scope of Overhaul

Equipment and parts to be overhauled, selection method and reasoning on the overhaul items, etc. will be described according to these for the overhaul executed by this project as an example.

③ Method of Inspection

Concerning the inspection methods based on visual, non-destructive, test- hammer, etc. selection method, principle and execution method will be described and transferred through OJT (On Job Training).

④ Planning of Works

Planning the overall plan on works including repair work, parts exchange work, etc., will be described according to these for the overhaul executed by this project as an example.

⑤ Execution Control

Work schedule control, quality control, materials control, safety control, etc. will be described.

⑥ Planning and Control of Budget

Planning and control of budget will be described according to these for the overhaul executed by this project as an example.

(2) Procurement Plan of Parts required for Major Overhaul

(a) Selection of parts to be procured

Due to the difficulty to shutdown the power plants in order to identify the parts required for overhaul, the inventory list (parts list) for equipment and materials was made by the team as the best alternative measure.

(b) Parts list to be procured for major overhaul

Base on this list, the analysis work was made by considering the information obtained at the aforementioned various surveys and it has been that about 6,000 equipment and parts stored in Banias power station can be used for major overhaul. On the basis of these information, the Team discussed the parts to be procured for major overhaul in detail with the manager and senior engineers in maintenance section. According to the above, the procurement plan for equipment and parts was made based on the ranking of priority at the stage of site survey.

(c) After back to Japan, the Team studied in more detail and made the procurement list of parts classified by priority ranking A, B and C.

(d) The team explained the parts ranked as A, and several items were changed and the lists were basically finalized through the discussion with the manager and senior engineers in maintenance section.

The agreed number of parts becomes approximately 15,000 and total amount including parts stored in the power station is 21,000.

Comparison of equipment and parts between request and basic design stages is shown in the Table 2-6,2-7,2-8 and the part selection factors are shown in the Table 2-9.

The procurement lists of pats agreed mutually are enclosed in Appendices (Data 6-4).

(e) Plan for tools and consuming materials.

Special tools will be needed to dismantle, inspect and maintain the equipment, also consumable materials will be needed for assembling was surveyed. As the survey result for the materials, these tools and consumable materials can be used for major overhaul, and will not procured in this project.

(3) Countermeasure for Flue Gas Pollution

It is decided to procure a following flue gas monitoring apparatus.

(a) Color CCD camera

(b) Color monitoring TV

Table2-6 Comparison between Request and Basic Design Stages (Boiler and Auxiliaries)

No.	Item	At Request Stage	(Detail of Change of Plan)
1	Boiler tubes	No request	Boiler tubes to be supplied for replacement Superheater tubes : 30 pcs. Reheater tubes : 30 pcs. Water wall tubes : 80 pcs.
2	Draft system	Bearings for 2 units	By status of operation and spare parts utilization, supply number of bearing is changed for 1 unit from 2 units.
3	Burner unit	No request for special parts	By survey on deterioration due to aging, seal tubes and dust covers required for 2 units are supplied.
4	Gas Air Heater	(1) Elements for 2units (2) No request for special parts	(1) Not supply of elements for high temperature parts because corrosion degree seems to be low. (2) Parts required for exchanging element will be supplied. -Rotor shell plate in low temperature part. -Diaphragm -Others
5	Sootblower	No request for complete set	As rotary soot blower was damaged, one set will be supplied.
6	Flue duct	No request	As thickness of flue gas duct is reduced due to low temperature corrosion from gas/air preheater to stack, materials for repair will be supplied from viewpoint of possibility of gas leakage and safety. -Steel plate for flue gas duct: 1.5boiler set -Casing and insulation materials: 1boiler set -Flexible joint:2 boiler sets
7	Safety valve	(1) Request for spring (b) No request for aux. valve	(1) Due to present status of actuating and repair, springs, upper/lowering, etc. will be deleted. (2) Disks and stems for auxiliary steam safety valves will be supplied due to damages.
8	Fuel system	No request	(1) Gaskets and packings required for overhaul will be supplied. (2) Complete set of fuel circulating pump will be supplied.
9	General valve	No request of HP bypass valve	Bypass valve of HP bypass spray control valve will be supplied due to damage.

Table 2-7 Comparison between Request and Basic Design Stages

(Turbine and Auxiliaries)

No.	Item		At Request Stage	Basic Design Stage (Detail of Change of Plan)
1	Lubricating Oil System	Gasket	Requested	No supply due to use Syrian gasket
		Filter	No Request	Supply due to oily condition
2	Feed Water Heater	Gasket	No Request	Supply for exchange work
		O Ring	No Request	Supply for exchange work
3	Feed Water Pump	Gasket	No Request	Supply for exchange work
		O Ring	No Request	Supply for exchange work

Table 2-8 Comparison between Request and Basic Design Stage

(C&I Equipment)

No.	Item		At Request Stage	Basic Design Stage Detail of Change of Plan
1	Recorder	Recorder on Control Board	Requested on Rank B	Supply due to failure
		Boiler Temp. Recorder	Requested on Rank C	Supply due to failure
		Turbine Temp. Recorder	Requested on Rank B	Supply due to failure
		Generator Temp. Recorder	Requested on Rank B	Supply due to failure
2	Sensing Device	Thermocouple	Requested on Rank B	Supply due to corrosion
		Transmitter	Requested on Rank B	Supply due to corrosion
3	Switches	Operation Switch	Requested on Rank B	Supply due to failure
		Pressure Switch	Requested on Rank B	Supply due to failure

Table 2-9 Procurement List of Parts alternated to Rank A

Equipment	Name	Parts	Selection Factor (*)	Ranking
Boiler and Auxiliaries	Boiler tubes	SH, RH, Wall tubes	d	A
	Draft fan	Bearing, Packing	e	A
	Burners	Gun, Swirler, etc.	c, d, e	A
	Gas Air Heater	Elements, Seal, etc.	b, c, d	A
	Sootblower	Valve, Gasket	c, d, e	A
	Flue gas duct	Plate, Lagging	a, c, d, e	A
	Safety valve	Disk, Stem, Gasket	c, e	A
	Level indicator	Glass, Lamp	a, c, e	A
	High press.valve	Disk, Stem, Packing	c, e	A
	Fuel equipment	Gasket, Packing	e	A
	Chemical equipment	Gasket, Packing	e	A
	Common equipment	Valve, Gasket, Packing	d, e	A
Turbine and Auxiliaries	HP, LP Turbine	Stud bolt, nut	e	A
	HP pedestal	Gasket, Oil seal	e	A
	Main valve	Diaphragm, Gasket	e	A
	Oil control unit	Diaphragm, Gasket	e	A
	Oil tank, cooler	Packing, O-Ring	e	A
	HP heater	Gasket, Oil seal	e	A
	Feed pump	Bearing, washer	e	A
Control Equipment	Boiler control	Valves, recorder, converter, etc.	d, e	A
	Turbine control	Control device, H2 gas system	d, e	A
Electric Equipment	Electric	Motor, Switch, Magnetic	d, e	A
	Generator	Washer, Diaphragm, Gasket	e	A
	Exciter	Washer, O-Ring, Oil seal	e	A
	Seal oil system	Bearing, Oil seal, Packing	e	A

(*) Selection Factor

a: visual inspection b: operation record c: failure record d: deterioration

e: annual inspection