DRAFT

PROJECT COMPLETION REPORT

OF THE

GUDDU 450.MW. COMBINED CYCLE PROJECT

(LOAN NO. 0660-PAK(SF)

AND

(LOAN NO. 0661-PAK)

IN

PAKISTAN

APRIL 26, 1989

Currency Equivalent

Currency Unit = Pakistan Rupees (Rs.)
1 Rs. = 100 Paisas

At Appraisal (November 1983)

$1 = Rs. 12.75
1 Rs. = $0.0783

At Project Completion (December 1988)

$1 = Rs. 19.50
1 Rs. = $0.0513

Since January 9, 1982, the Pakistan Rupee has been delinked from U.S. Dollar. Pakistan now maintains a managed floating exchange rate based on a weighted basket of currencies of the country's major trading partners. The rupee - U.S. Dollar parity is fixed daily.

ELECTRICAL TERMINOLOGY

V	(Volt)	-	Unit of voltage
kV	(Kilovolt)	-	1,000 volts
W	(Watt)	-	Unit of real power
kW	(Kilowatt)	-	1,000 watts
MW	(Megawatt)	-	1,000,000 watts
MVAr	(Megavar)	-	1,000,000 volt-ampere-reactive
Wh	(Watt-hour)	-	Unit of energy
kWh	(Kilowatt-hour)	-	1,000 Wh
GWh	(Gigawatt-hour)	-	Million kWh
Load factor		-	Ratio of average power demand to maximum power demand
Systems losses		-	Energy losses incurred in power system networks and equipment
Plant factor		-	The ratio of actual capacity utilization of the plant to its maximum possible capacity utilization
Reliability factor		-	The per cent of time the unit is in operation. It is equal to the hours the unit is in operation divided by the total hours in the period under consideration.
Availability factor		-	The per cent of time the unit is available for services, whether operated or not. It is equal to available hours divided by the total hours in the period under consideration.

ABBREVIATIONS

ADB	Asian Development Bank (The Bank)
WAPDA	Pakistan Water and Power Development Authority
USAID	United States Agency for International Development
G&H	Gibbs & Hill Inc., U.S.A.
NESPAK	National Engineering Services Pakistan (Pvt.) Limited
GE	General Electric Company, U.S.A.
MLC	MacDonald Layton & Company
KSEW	Karachi Shipyard & Engineering Works
SF	Special fund
SDR	Special drawing rights
STAG	GE trade mark for their Combined Cycle Plant
OCR	Ordinary Capital Resources

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

GUDDU 450 MW COMBINED CYCLE POWER PLANT PROJECT

PROJECT COMPLETION REPORT

DRAFT

PREPARED BY

GIBBS & HILL INC.

FOR

THE ASIAN DEVELOPMENT BANK

APRIL 26, 1989

TABLE OF CONTENTS

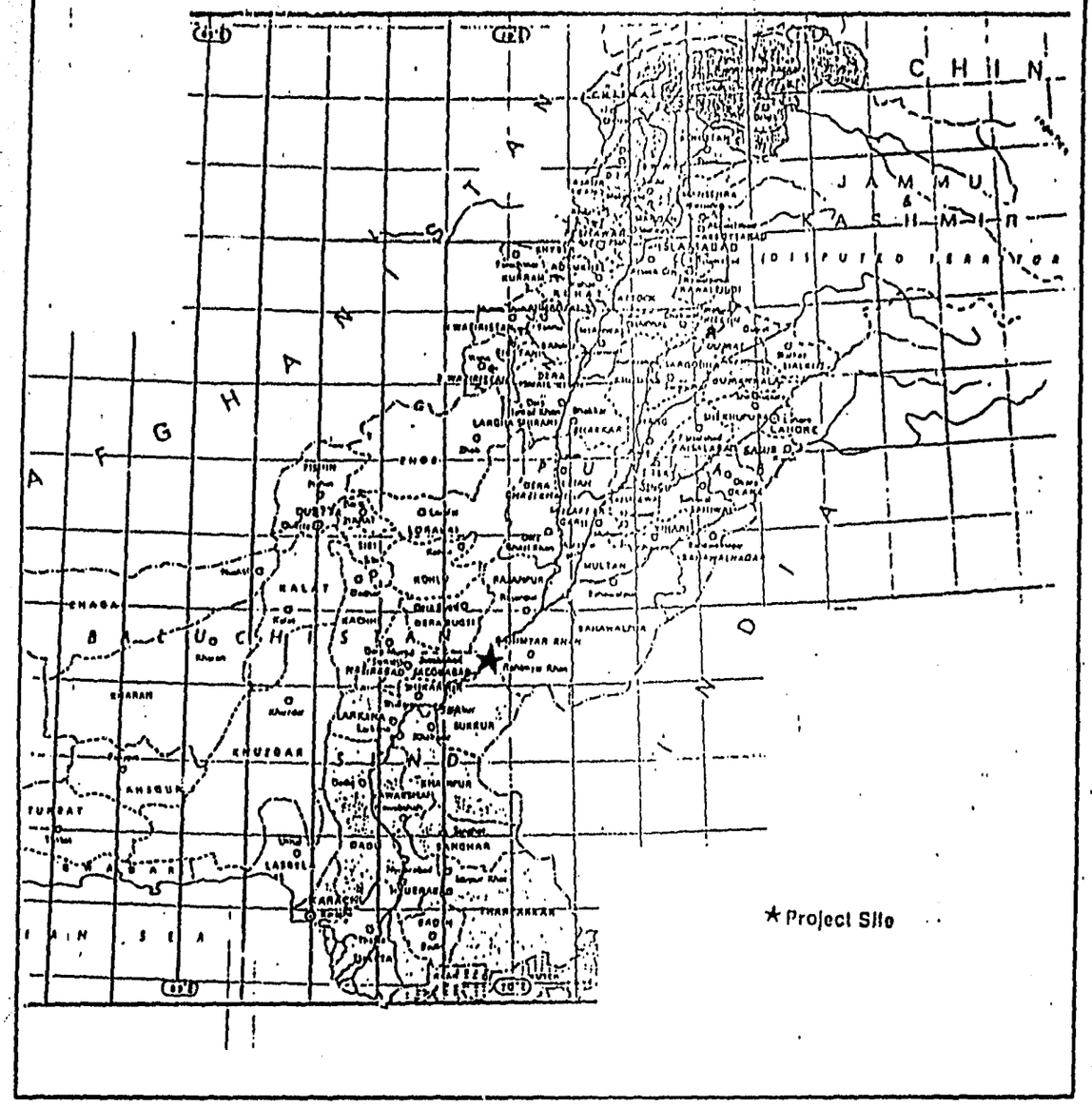
TABLE OF CONTENTS (Cont'd)

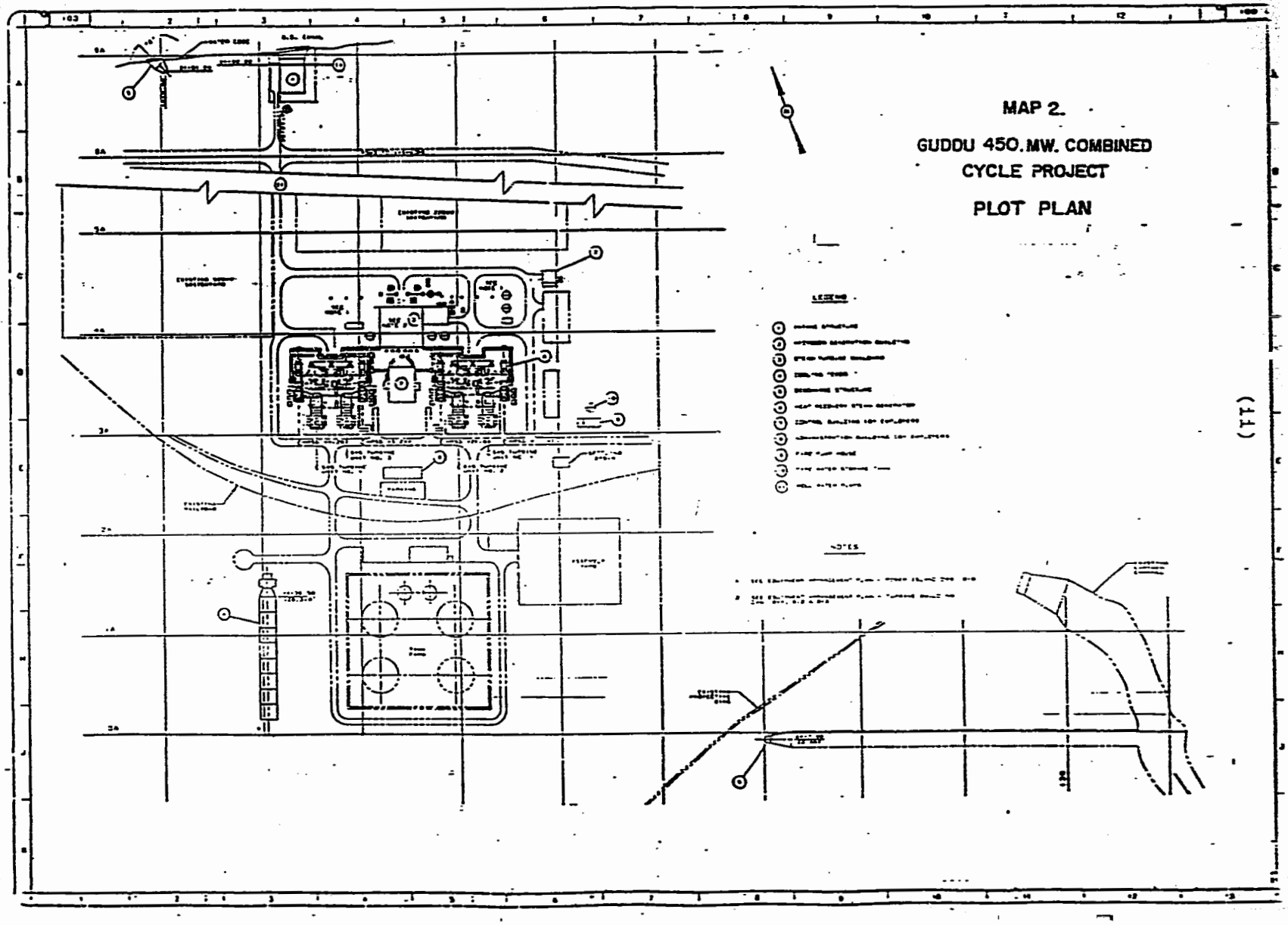
MAPS AND FIGURES

(1)

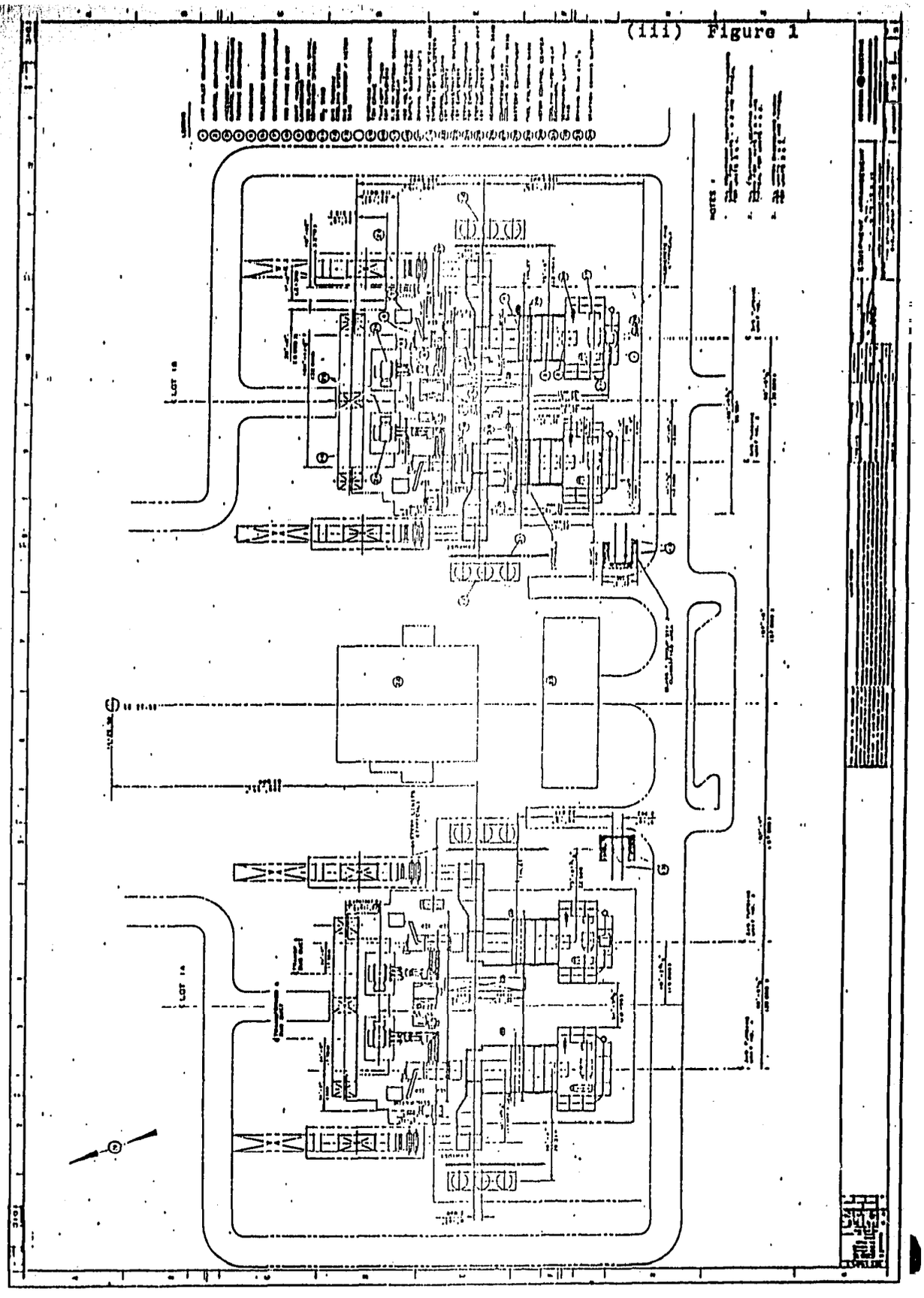
MAP I

Location of Guddu Site and Pakistan

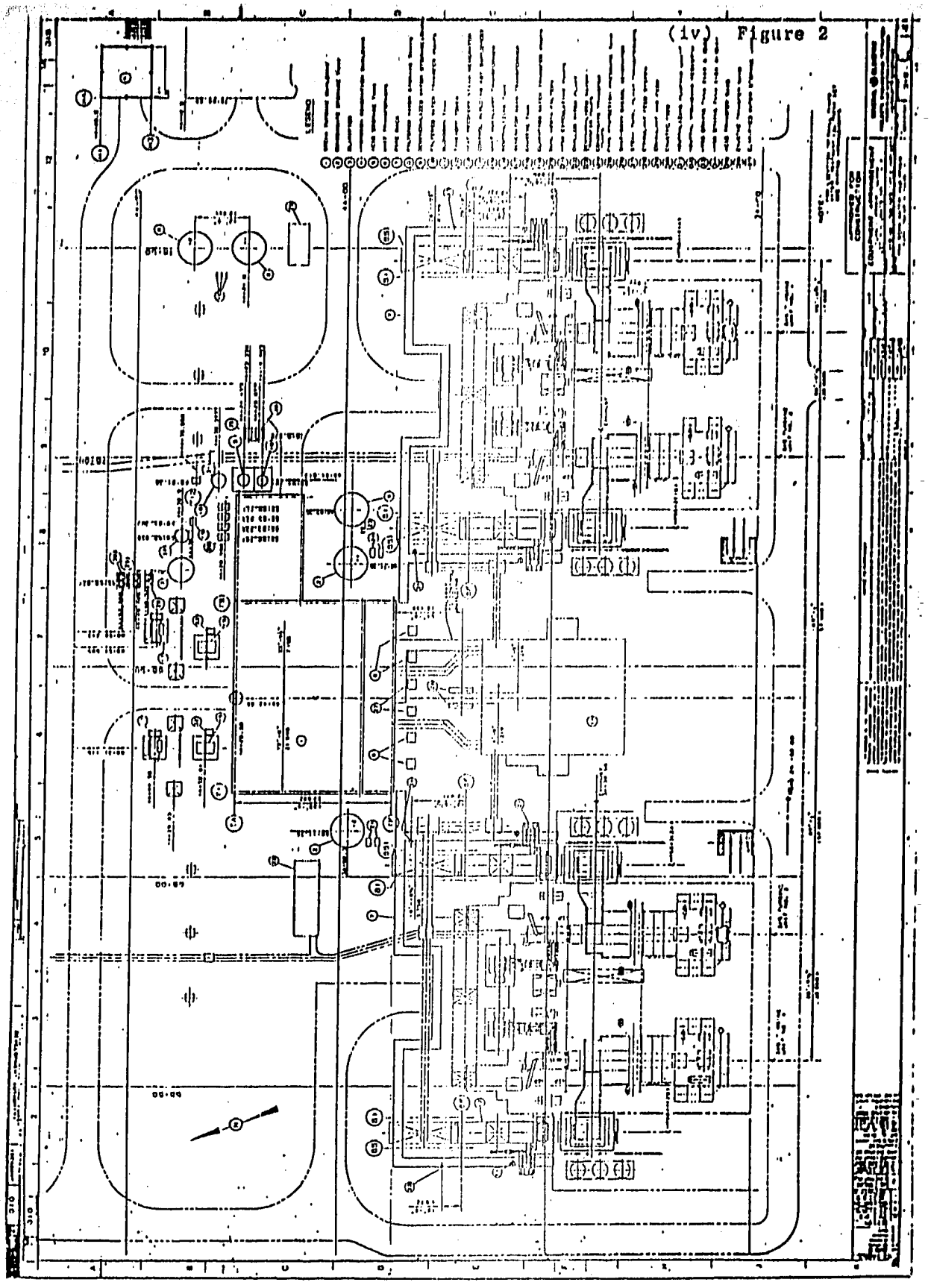




(iii) Figure 1



(iv) Figure 2



(v) Figure 3

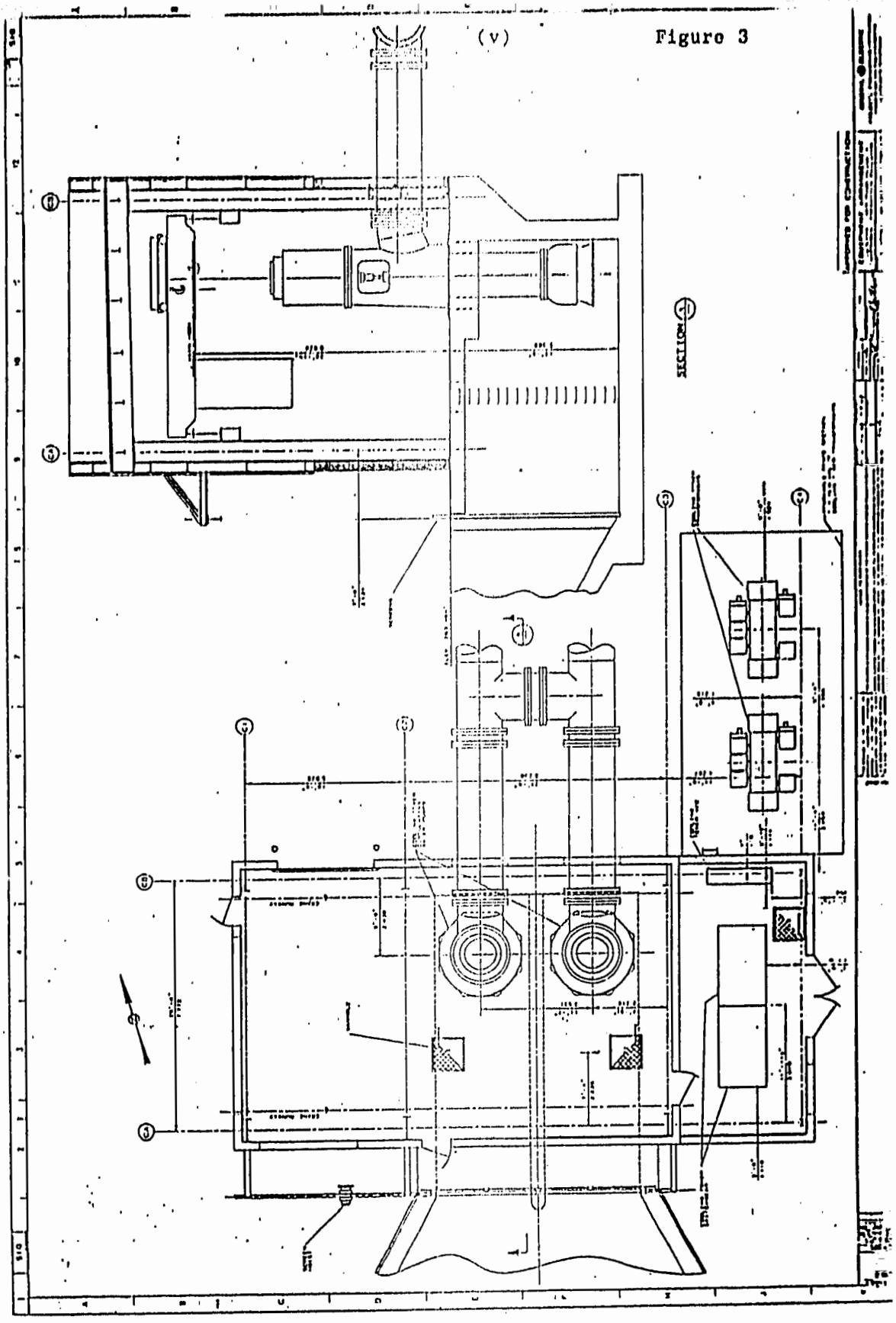
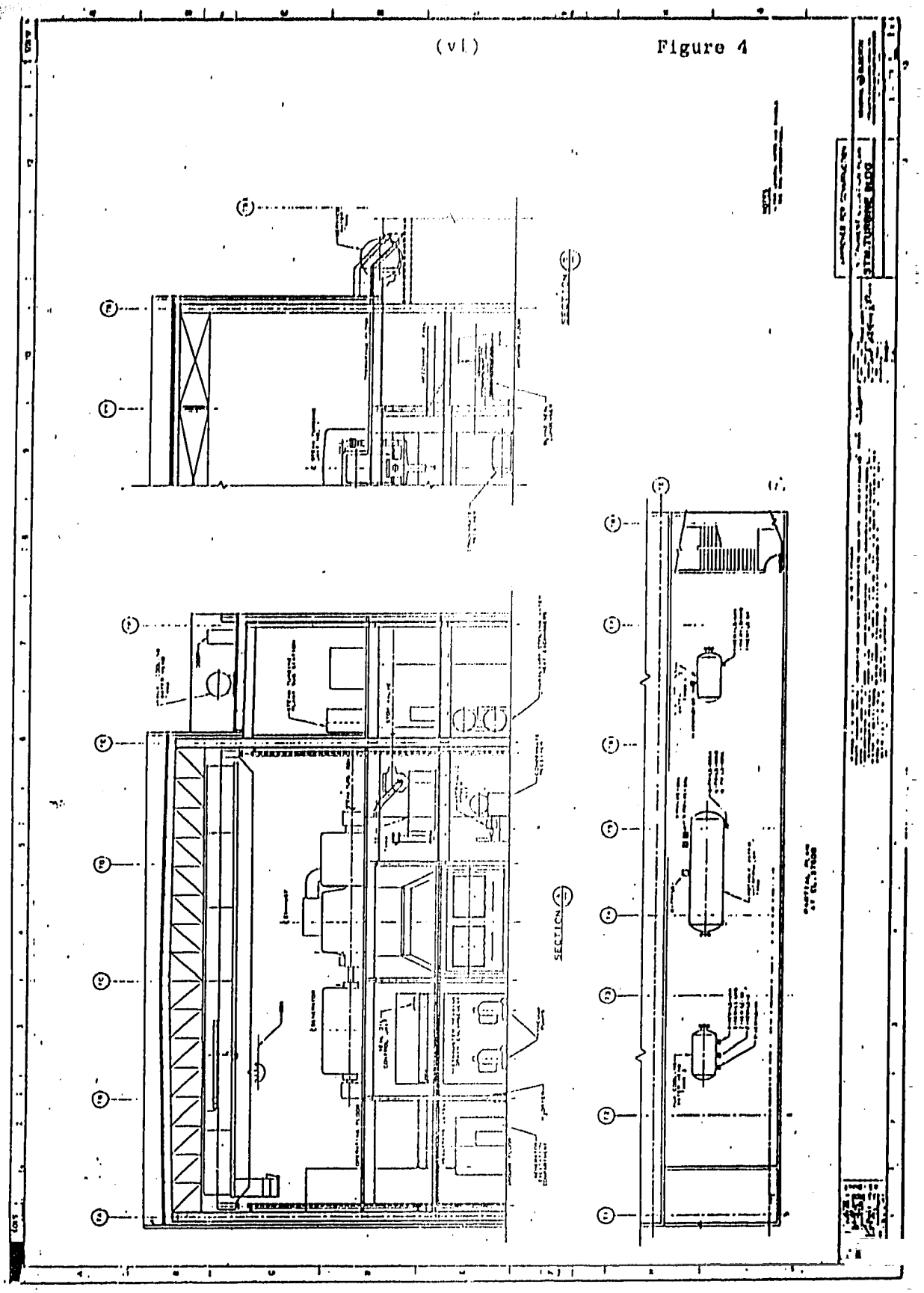


Figure 4



(vii) Figure 5

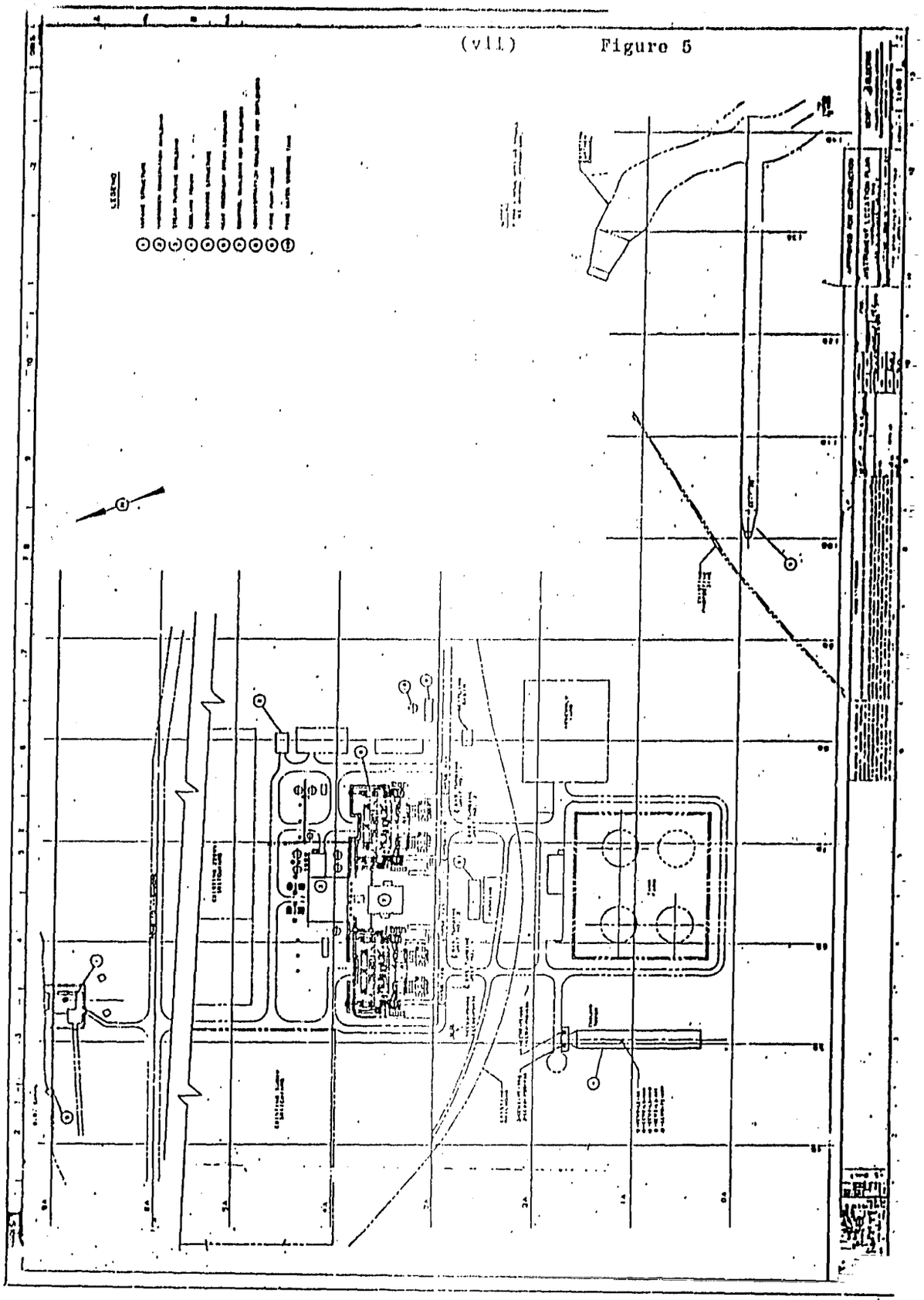
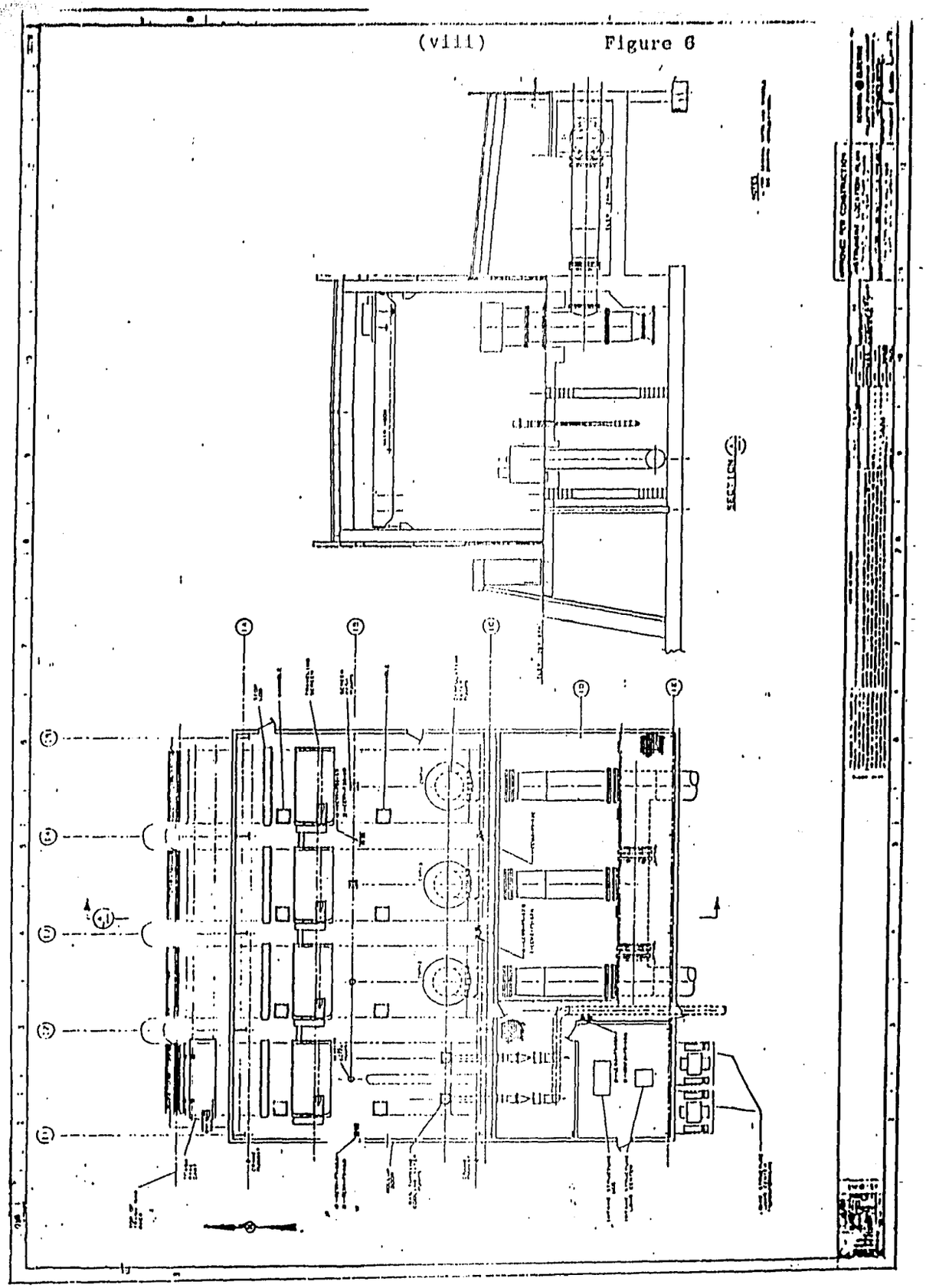
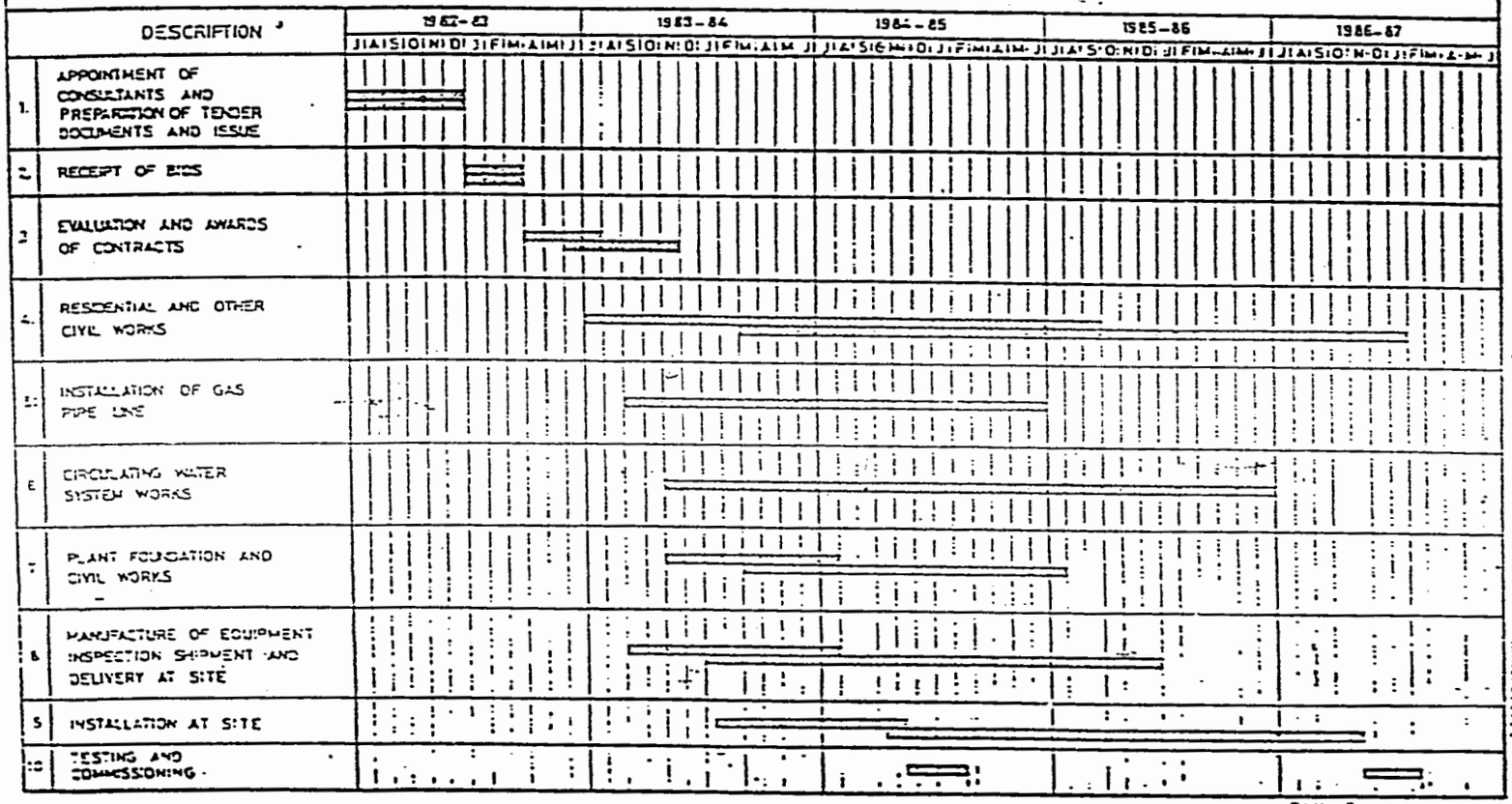


Figure 6



PROJECT CONSTRUCTION SCHEDULE
450 MW COMBINED CYCLE POWER PLANT
AT G U D D U

LEGEND
PHASE - I
PHASE - II



(Source: WAPDA Pro-Forma PC-1 for the Guddu 450 MW Combined Cycle Power Plant Project, August 1982)

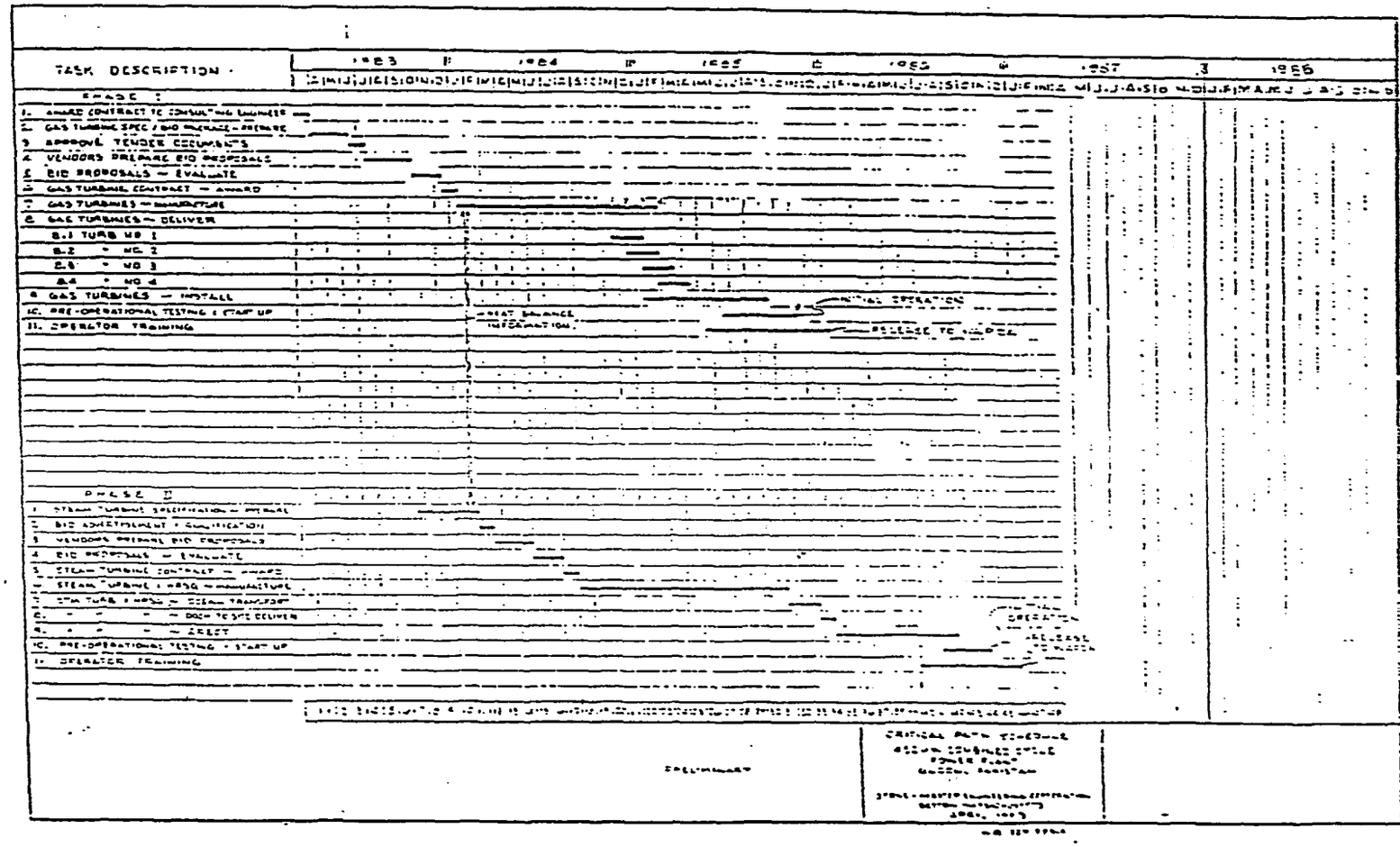
DRAWN By Javed Akhter

FIGURE 7

Annexure-II

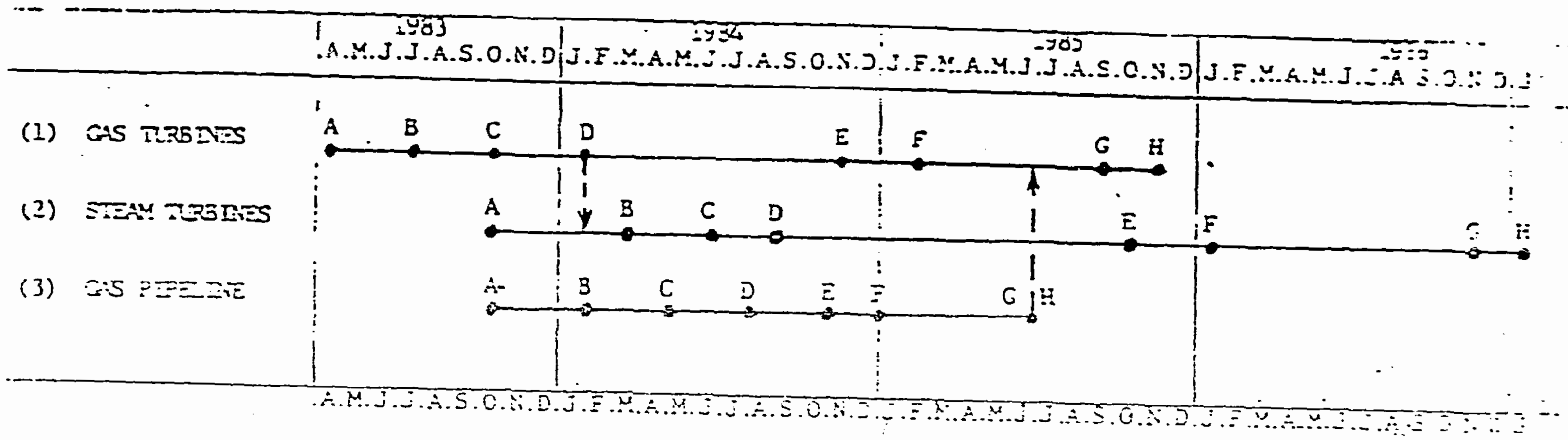
(ix)

65



(Source: Rural Electrification Gas Turbine Combined Cycle Power Generation Facility Guddu, Pakistan: An Update on Estimated Cost, Schedule, Bid Packaging and Economic/Financial Analysis - Prepared by the Stone & Webster Engineering Corporation for USAID, April 1983).

WAPDA: GUDDU COMBINED CYCLE PROJECT
IMPLEMENTATION SCHEDULE



LEGEND:

AB	=	Preparation of Bidding Documents
BC	=	Tendering Period
CD	=	Tender evaluation
D	=	Contract Award
DE	=	Manufacture
EF	=	Ship
FG	=	Construction
GH	=	Commissioning
H	=	Commercial operation

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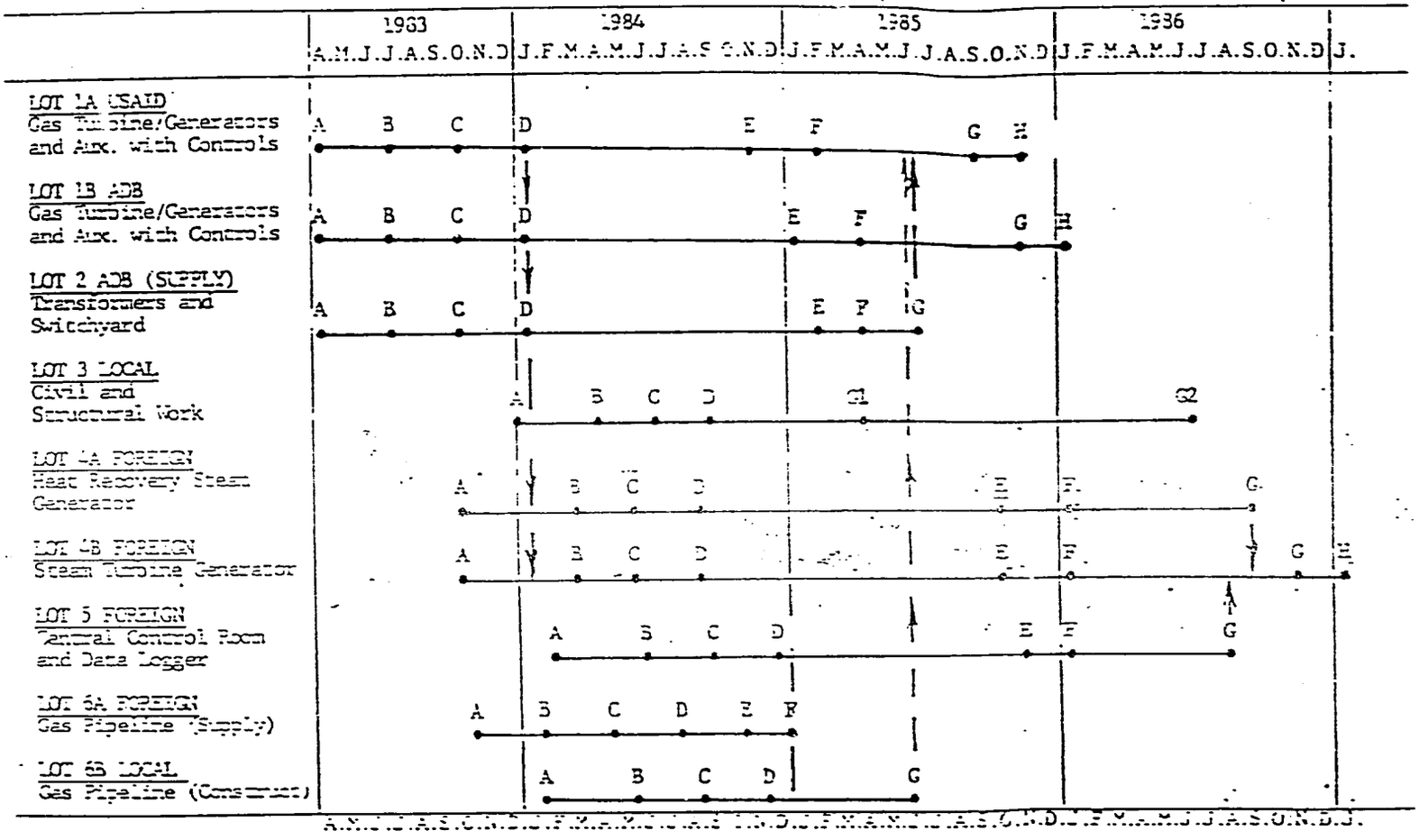
FIGURE 8
Page 1 of 2

(xi)

18

WAPDA GUDDU COMBINED CYCLE PROJECT
Contract Milestone Schedule



LEGEND:

AB	= Preparation of Bidding Documents	DM	= Manufacture
BC	= Tendering Period	DT	= Ship
CD	= Tender Evaluation	FC	= Construction
D	= Contract Award	GH	= Commissioning
		H	= Commercial Operation

BASIC DATA SHEET

A. LOAN IDENTIFICATION

1.	Country	Islamic Republic of Pakistan
2.	Loan Numbers	0661-PAK and 0660-PAK(SF)
3.	Project Title	Guddu 450 MW Combined Cycle Power Plant
4.	Borrower	Islamic Republic of Pakistan
5.	Executing Agency	The Pakistan Water and Power Development Authority
6.	Amount of Loans	0661-PAK $ 57.5 million 0660-PAK (SF) $ 83.4 million Total $ 140.9 million

B. LOAN DATA

1. Appraisal

- Date Started	November 1983
- Date Completed	

2. Loan Negotiations

- Date Started	September 1983
- Date Completed	December 6, 1983

3.	Date of Board Approval	December 6, 1983
4.	Date of Loan Agreement	December 29, 1983

5. Date of Loan Effectiveness

- In Loan Agreement	March 28, 1984
- Actual	November 2, 1984
- Number of Extensions	

6. Closing Date

- In Loan Agreement	August 31, 1987
- Actual	Not yet closed
- Number of Extension	One

7. Terms of Loan

	0660-PAK(SF)	0661-PAK
- Interest Rate	0	10.5%
- Service Charge	1%	0.75%
- Bank Fee	0.5%	0.75%
- Maturity (No. of years)	30	25
- Grace Period (No. of years)	10	5

8. Terms of Relending

- Interest Rate	11%
- Maturity (No. of years)	25
- Grace Period (No. of years)	5

9. Disbursements

- Date of Initial Disbursement	December 21, 1984
- Date of Final Disbursement	
- Amount Disbursed	
- Amount Cancelled	

10. Local Cost (Financed) N/A

C. PROJECT COST DATA

	Appraisal Estimate	Actual Total
1. Project Cost ($ millions)		
a) Foreign Currency Cost	206.9	188.60
b) Local Currency Cost	155.3	66.12
c) Total	362.2	254.72
2. Financing Plan ($ million)		
a) Bank Financed	140.9	114.26
b) Other Financed (USAID)	52.0	56.81
c) Local Financed	169.3	83.65
d) Total	362.2	254.72
3. Cost Breakdown by Project Components		
a) Gas Turbine-Generators	90.9	81.29
b) Transformer and Switchyard	12.1	4.62
c) Steam Plant	76.4	63.20
d) Central Controls	2.8	0
e) Gas Pipeline	7.0	4.35
f) Engineering Services	3.7	14.56
g) Interest during Construction	14.0	17.53
h) Other	155.3	69.17
i) Total	362.2	254.72

4. Project Schedule

The WAPDA "Proforma PC-1" schedule (figure 7) which was issued in August 1982 showed Phase I (the gas turbine plant) as being commissioned by mid-February 1985 and Phase II (the combined cycle add-on) as being commissioned by mid-March 1987. Phase I was to be completed within 18-1/2 months of the award of gas turbine contract and Phase II was to be completed within 38-1/2 months of the award of contract for the HRSG's and steam turbine-generators.

The schedule prepared by Stone & Webster in April 1983 (figure 8) showed Phase I as being completed by mid-January 1986 and Phase II as being completed by mid-February 1987. Phase I was to be completed within 24 months of award of the gas turbine contract while Phase II was to be completed within 28-1/2 months of the HRSG's and steam turbine plant contract. The Stone & Webster schedule is considered to be the reference schedule for comparison purposes.

The project schedule included in the Bank's appraisal report issued in November 1983 (figure 9), showed Phase I (the gas turbine plant) as being commissioned by November 1985 and Phase II (the combined cycle add-on) as being commissioned by January 1987. Phase I was to be completed within 21 months from the award of the contract while Phase II was to be completed within 29 months from the award of the contract for the HRSG's and steam turbine-generators.

A comparison of key dates between the appraisal schedule and actual performance is as follows:

Schedule

	Appraisal	Actual
Lot 1A: Gas turbine plant		
Contract award	January 15, 1984	June 28, 1984
Initial Operation Unit No. 3	September 15, 1985	March 4, 1986
Initial Operation Unit No. 4	September 15, 1985	March 12, 1986
Taking Over Unit No. 3	November 15, 1985	March 6, 1986
Taking Over Unit No. 4	November 15, 1985	April 12, 1986
Lot 1B: Gas turbine plant		
Contract award	January 15, 1984	June 28, 1984
Initial Operation Unit No. 1	November 15, 1985	November 28, 1985
Initial Operation Unit No. 2	November 15, 1985	December 27, 1985
Taking Over Unit No. 1	January 15, 1986	December 20, 1985
Taking Over Unit No. 2	January 15, 1986	March 30, 1986
Lot 4: Combined cycle add-on		
Contract award	September 1, 1984	March 16, 1986
Initial Operation Unit No. 1	November 15, 1986	December 27, 1987
Initial Operation Unit No. 2	November 15, 1986	March 22, 1988
Taking Over Unit No. 1	January 15, 1987	November 19, 1988
Taking Over Unit No. 2	January 15, 1987	August 21, 1988

Data on Bank

Date	Type of Mission	Mandays
(To be completed by Bank)		

23

I. PROJECT DESCRIPTION

A. Scope, Objectives and Rationale

1. Introduction:

1. On December 6, 1983 the Asian Development Bank approved two loans No. 661-PAK and 660-PAK in the amount of US $ 140.9 million for the Guddu 450 MW Combined Cycle Power Plant Project. The borrower for the project was the Islamic Republic of Pakistan and the executing agency was the Pakistan Water and Power Development Authority (WAPDA). Please see Appendices 12 and 13.

The cost of the project was estimated to have a foreign exchange component of US $192.9 million (excluding interest during construction). The ADB loan was supplemented by financing of US $52 million from the United States Agency for International Development (USAID). The ADB and USAID financing was intended to cover the construction of two combined cycle units (with each unit comprising two (2) 100 MW gas turbines, two (2) heat recovery steam generators and one (1) 100 MW steam turbine and its auxiliaries), an extension to the existing 220 kV switchyard, central controls, the construction of a 65 Km gas pipeline and engineering services. The 450 MW nominal rating corresponds to an ambient air temperature of 50°C. The plant output at 27°C is approximately 600 MW.

2. Project Scope

2. The project consisted of two phases: Phase 1 comprised the gas turbines, switchyard and gas pipeline and phase II comprised the combined cycle add-on. The scope of the project as envisaged at appraisal is given in detail in Appendix 2 and summarized below:

(i). Phase I:

(a). Installation of four gas turbine-generators

(b). Construction of Mari-Guddu gas pipeline

(c). Erection of the 220 kV switchyard extension

(d). Associated auxiliary plant and equipment

(ii). Phase II:

(a). Installation of four (4) Heat Recovery Steam Generators (HRSG's)

(b). Installation of two (2) Steam Turbine-Generators

(c). Associated auxiliary plant and equipment

3. Project Objectives and Rationale

3. The project was conceived in the context of WAPDA's pressing need to narrow the expanding gap between the supply and demand of electrical power in Pakistan. This project was part of Pakistan's sixth (6th) five year plan (1983-1987/88) for the development of the energy sector. The rationale for the project considered the higher efficiency of a combined cycle plant (vis-a-vis a conventional thermal unit), the use of an indigeneous energy resource, anticipated plant reliability and relatively short construction schedules, particularly for the gas turbine units.

4. The specific objectives of the project were to:

(a) Provide base load generating capacity which would assist in minimizing load shedding during the winter months when hydroelectric power generation is curtailed due to the reduced flow of water in the rivers.

(b) To provide additional peaking capacity.

B. Implementation Methods Used

5. The four (4) gas turbines were originally scheduled to be commissioned by January 1986 with earlier commissioning of the gas pipeline and the 220 kV switchyard expansion. The two steam turbine-generators were scheduled to be commissioned by January 1987.

The project was financed by the Asian Development Bank (ADB), the United States Agency for International Development (USAID) and the Government of Pakistan (GOP).

Project Implementation was as follows:

i. WAPDA established a project team led by a Project Director reporting to the WAPDA General Manager (Thermal) through the Chief Engineer (Design and Development) Thermal.

ii. Technical and economic feasibility studies were prepared by the ADB and a USAID financed U.S. based consulting firm (Stone & Webster Engineering Corporation). Stone & Webster also prepared the "bid packages" for the gas turbines and switchyard extension.

iii. USAID engaged a U.S. based architect-engineering firm (Gibbs & Hill Inc.) which, reporting to WAPDA and together with a local engineering consulting firm appointed by WAPDA, was responsible for the conceptual design of the plant, preparation of bid packages, review and evaluation of proposals, monitoring of equipment manufacture, and overall coordination and monitoring of all site activities through mobilization, construction, start-up and commercial operation.

iv. WAPDA entered into a number of turnkey type contracts ("lots") for the design, supply, installation and commissioning of the plant facilities. The foreign currency component of the major contracts involving imported equipment was financed either by the ADB or by

USAID. These included the gas turbine-generators, the HRSG's, steam turbine-generators and auxiliary equipment, the switchyard extension and material and equipment for the gas pipeline. Contracts for initial site preparation, the control and administration buildings, the warehouse and workshop, the construction of the gas pipeline, the fuel oil tanks and other auxiliary facilities were executed by local contractors under local rupee financing.

v. Foreign and site training of WAPDA personnel was provided by the turnkey plant suppliers.

II. PROJECT HISTORY

6. A brief history of the project's major components of Phases I and II components is as follows:

Phase I

1. Lot 1A; Two (2) Gas Turbine-Generators and Accessory Equipment

The Tender documents for the supply, erection and commissioning of two (2) gas turbine-generator sets and accessory equipment were issued on July 15, 1983. Bids were received and opened on October 31, 1983. A contract was signed between WAPDA and the General Electric Company of U.S.A. on September 26, 1984.

Gas turbine-generator units 3 and 4 were taken over by WAPDA on March 6, 1986 and April 12, 1986 respectively.

2. Lot 1B; Two (2) Gas Turbine-Generators and Accessory Equipment

The Tender documents for this work were issued along with Lot 1A and the contract was also signed on the same date i.e. September 26, 1984.

Gas turbine-generator units 1 and 2 were taken over by WAPDA on December 20, 1985 and March 30, 1986 respectively.

3. Lot 2: Main Step-Up Transformers for Gas Turbine-Generators and 220 kV Switchyard Extension

The Tender documents for the supply, erection and commissioning were issued on July 15, 1983. Bids were received on November 1, 1983 and the contract between WAPDA and Imperial Construction Company of Pakistan was signed on July 25, 1984.

Erection and commissioning of the transformers and switchyard extension work was completed on December 20, 1985 and March 31, 1986 respectively.

Phase II

4. Lot 4: Four (4) Heat Recovery Steam Generators (HRSG's), Two (2) Steam Turbine-Generator (STG's) and Balance of Plant (BOP)

The Tender documents for the supply, erection and commissioning of Lot 4 - Four (4) HRSG's, Two (2) Steam Turbine-Generators and Balance of Plant (BOP) were issued on August 17, 1984. Bids were received on January 29, 1985. The price envelopes were opened on January 15, 1986 after the technical evaluation was completed. The Letter of Intent to the award a contract was issued to the General Electric Company (GE) of the U.S.A. on February 19, 1986. The contract between WAPDA and GE was signed on March 19, 1986 with effect on March 16, 1986.

GE started construction at the site in June 1986. By the end of 1986 it became apparent that the completion schedule was not on target. Estimated site progress at the end of the year was 15 percent against the approximately 40 percent required to meet the contract schedule. Much of this delay was attributed to the non-availability of equipment and material at site. Although the pace of material deliveries increased during early 1987, and by March over 40 percent completion was achieved, progress was still below the required level.

In order to expedite power generation workaround schemes were developed whereby only those systems that were required to bring the plant on line were commissioned. The remaining work was to be completed after the plant started generating power. As a result, even though the machines started generating power in December 1987 and March, 1988 the plant was not considered substantially complete until early 1989.

As the systems became available and completed, they were taken over by WAPDA. Following is a list of taking over packages accepted by WAPDA todate:

1.	Hydrogen Generation Plant	February 3, 1988
2.	Gas Chromatograph	April 15, 1988
3.	Stag Unit No. 2 HRSG's and Balance of Stag Unit No. 2	August 21, 1988
4.	Stag Unit 1 HRSG's and Balance of Stag Unit No. 1	November 19, 1988
5.	Cooling Tower	December 21, 1988
6.	Water Treatment Plant	February 15, 1989

The systems that are still to be completed include the plant microprocessor based control system and "punch list" items.

5. Lot 5C: Central Chilling and Heating Plant

The tender document for the supply, erection and commissioning of Central Chilling and Heating Plant was issued on May 8, 1985. Bids were received on October 27, 1985. The contract was signed between WAPDA and General Electric Company of U.S.A. on February 10, 1987.

The plant was taken over by WAPDA on May 21, 1988. The guarantee period of the plant is due to be completed on May 21, 1989.

6. Lot 6A & 6B: Gas Pipeline Material Supply and Erection

The Tender documents for the supply of Natural Gas Pipeline Material (Lot 6A) including Gas Mixing Station and Dehydration Plant were issued on October 12, 1984. Bids were received and opened on December 24, 1984 and the contract was awarded to various suppliers on April 4, 1985.

Commissioning of the Mari-Guddu Gas Pipeline (Lot 6B) was completed on June 15, 1986 although Mari gas was first delivered to Guddu in February 1986.

Chronology of major events in the history of the project are summarized in Appendix 1.

A. Design and Appraisal

1. Introduction

7. In 1983 the Government of Pakistan proposed that the Bank finance the foreign currency portion of the 450 MW Combined Cycle Project at Guddu to comprise four (4) gas turbine-generators and two steam turbine-generators rated at 100 MW each.

In consideration of the feasibility studies prepared by consultants in 1983, the project was appraised by the ADB and a report submitted in November 1983.

8. The appraisal mission considered the project well conceived, technically feasible and economically viable. In view of the WAPDA's experience in the implementation of the previous projects financed by the bank, the appraisal mission considered that WAPDA was fully familiar with the Bank's guidelines on the use of consultants and guidelines for procurement as well as with the standard loan conditions, and therefore, was competent to undertake the project.

9. On December 6, 1983 the Bank approved two loans; one for $57.5 million from its ordinary capital resources with repayment terms of 25 years including a 5 year grace period, and another loan of $ 83.4 million in Special Drawing Rights (SDR) from the Bank's special fund resources at standard terms of the bank with repayment in 30 years including a grace period of 10 years.

The borrower of both the loans, was the Islamic Republic of Pakistan, which relent the proceeds of the loan to WAPDA, the executing agency for the project.

Additional financing in the amount of U.S. $52 million was provided by USAID. This financing was needed to meet the estimated total foreign exchange requirements of the project.

The foreign exchange cost of interest during construction ($14 million) was to be met by the Government of Pakistan through WAPDA.

2. Key Issues Identified During Appraisal

10. In addition to the standard provisions and requirements embodied in the loan and project agreements of the Bank, the following issues were identified:

i. As a condition of loan effectiveness a gas supply contract between WAPDA and the operator of the Mari gas was to be signed (Loans Agreement section 6.01(d))

ii. The borrower (Islamic Republic of Pakistan) and WAPDA have agreed to maintain a three year average self-financing ratio of 40 percent for 1982/83 and thereafter. (Special Operations loan agreement schedule 6, para 5)

iii. WAPDA has given assurances that total electricity losses will not exceed 27 percent by June 30, 1984 and 23 percent by June 30, 1986. (Special Operations loan agreement schedule 6, para 7)

iv. WAPDA were to undertake a comprehensive tariff study to be completed not later than June 30, 1984. (Special Operations loan agreement, schedule 6, para 8)

v. The Borrower and WAPDA were to keep the Bank informed of the major institutional change in the power sector. (Special Operations loan agreement, schedule 6, para 10)

3. Project Components and Cost Estimates

11. Project components as envisaged at appraisal are given in Appendix 2. The total cost estimate of the project was at $362.2 million, of which the foreign currency component was $206.9 million.

12. The base cost of the project was adjusted to January 1983 prices. A provision of 5 percent for physical contingencies on all base costs were included. Bank prescribed price escalation rates were applied, which is summarized below:

	Price Escalation Rates Applied	
	Foreign Cost	Local Cost
1983	8%	11%
1984	7.5%	11%
1985	7%	11%
1986 and thereafter	6%	11%

13. A summary of the appraisal cost estimate is shown in Table 1:

TABLE 1
APPRAISAL COST ESTIMATE
(IN MILLIONS OF DOLLARS)

Description	Foreign Currency	Local Currency	Total
Gas turbine-generators[1/]	77.6	3.3	80.9
Transformers and Switchyard	10.3	1.1	11.4
Civil Works	-	19.5	19.4
Steam Plant and Electrical[1/]	65.4	12.4	77.8
Central Controls	2.3	0.3	2.6
Gas Pipeline	6.0	4.2	10.2
Engineering Services	3.7	0.3	4.0
Sub-total	165.3	41.1	206.4
Taxes and duties	-	74.4	74.4
Physical Contingencies	8.0	2.1	10.1
Price Contingencies	19.6	9.2	28.8
Interest during Construction	14.0[2/]	28.5	42.5
Sub-total	41.6	114.2	155.8
TOTAL	206.9	155.3	362.2

1/ Packages include a total of $600,000 for training of staff.
2/ Will be paid by WAPDA to the Government in local currency.

14. In view of the magnitude of the estimated cost of the project, it was proposed that the project be co-financed by USAID. The foreign currency cost of the project of $192.9 million was to be financed by two loans from the bank (totalling $140.9 million) and financing from USAID ($52 million). The foreign currency cost of interest during construction ($14 million) would be met by the Government through WAPDA, as mentioned earlier. The local currency component of the project cost, equivalent to $155.3 million was to be financed by WAPDA. The financing plan is shown in Table 2:

TABLE 2
Financing Plan (Foreign Currency Only)
($ Million)

	Foreign Cost	ADB		USAID	Government
		OCR	SF		
Gas turbine-generators	90.9	45.4	-	45.5	-
Transformers and switchyard	12.1	12.1	-	-	-
Steam plant	76.4	-	76.4	-	-
Central controls	2.8	-	-	2.8	-
Gas pipeline	7.0	-	7.0	-	-
Engineering Services	3.7	-	-	3.7	-
Interest during construction	14.0	-	-	-	14.0
	206.9	57.5	83.4	52.0	14.0

B. Implementation

1. Project Components

15. There were few changes in project components and implementation methods. Those changes were insignificant and were of the type that would be expected on a project of the size and complexity of a power generating plant. The changes included the following:

i. The plant arrangement which was developed at the feasibility study stage was changed. In the original plan, the Central Control Building was to be placed between the Combined Cycle Units 1 & 2 while the Steam Turbine Building was located between the Central Control Building and the existing rail road track on the south side.

The revised plan, while leaving the Central Control Building in its original location, moved the Steam Turbine Building to the north side and locatd it between the Central Control Building and the 220 kV Switchyard. The cooling tower location was also changed from east side of the plant to the west side and on the south side of the railroad track.

ii. It was originally intended that all civil and structural works would be furnished under local rupee financed contracts (Lot 3). However it was realized that in many cases (e.g. the gas turbine foundations, the steam turbine building, the circulating water intake and discharge structures, the HRSG foundations and the cooling tower foundations and basin) this approach would result in logistic and management problems with the potential for unfavorable impact on both schedule and costs. Civil and structural works such as those referred to above were therefore included in the turnkey packages for the associated gas turbines, steam turbine plant etc.

iii. The combined cycle add-on was originally envisaged as being supplied under two turnkey contracts; Lot 4A for the HRSG's and auxiliaries and Lot 4B for the steam turbine-generators and balance of plant. At the time of preparation of the Lot 4A and Lot 4B tender documents it was decided that proposals would also be accepted for the add-on as a single contract (Lot 4). The Lot 4 proposals which were tendered were evaluated against the lowest evaluated combined Lot 4A and Lot 4B proposals. The Lot 4 proposal submitted by the General Electric Company was evaluated lowest and therefore Lot 4 replaced the separate Lots 4A and 4B.

iv. Lot 5 was originally designated as the "central control facility and data logger" and was intended to include the plant control board, a data logger, cable trays and wiring, and control room facilities such as lighting and HVAC equipment. The supply of the control panels was subsequently transferred to the main turnkey packages and Lot 5 was divided into three sub-lots. The data logger was designated Lot 5A. A plant simulator was proposed as an additional item and designated Lot 5B. The central control facility heating and chilling plant was designated Lot 5C. Lot 5A was subsequently abandoned as s separate contract since the Lot 4 contractor offered a plant control system with data logging capability. It was also decided not to proceed with the Lot 5B simulator. The original Lot 5 was therefore reduced to Lot 5C, the heating and chilling plant.

v. A number of components and items of equipment were procured from foreign sources outside the supply of the main turnkey packages. These procurements were necessitated by unforeseen project developments and were financed by both the ADB and USAID. To give one example, it became evident in mid-1985 that the gas pipeline and gas mixing station would not be available to support the initial start-up of the first two gas turbines. A

standby pressure reducing station, valves and piping were procured under ADB financing to enable a tie-in to the Sui gas line. This enabled gas turbines units 1 and 2 to be commissioned utilizing Sui gas.

vi. There were no changes in the overall implementation methods.

2. Project Costs

16. Actual project expenditures breakdown into major components is shown in Appendix 4.

17. A comparison of actual expenditure with the appraisal cost estimates shows that there were substantial cost underruns in the foreign and local currency costs, as shown in Table 3:

TABLE 3
Cost Underruns
($ Million)

Description	Appraisal	Actual	Underrun	Percentage
Foreign Currency Cost	206.9	188.60	18.30	8.85
Local Currency Cost	155.3	66.12	89.18	57.42
Total	362.2	254.72	107.48	29.67

As a result of the foreign currency underrun financing for the project from the Bank and USAID differed from the financing plan anticipated at appraisal.

3. Recruitment of Consultants

18. As envisaged during appraisal, USAID extended the services of the short term Consultants, Stone & Webster Engineering Corporation, U.S.A. to undertake the drafting of the bidding documents for contract packages Lots 1A/1B - gas turbine-generators and accessories, and Lot 2 - main step-up transformers and switchyard extension. These two packages were issued for international bidding in July 1983.

USAID rules require that the long term engineering consultant be engaged under open competition among consultants from U.S.A. USAID with the Bank's concurrence, selected Gibbs & Hill Inc., U.S.A. for the consultancy services. Gibbs & Hill Inc., commenced their project activities in November 1983. The scope of the engineer's services is described in Appendix 6.

19. WAPDA appointed National Engineering Services of Pakistan (NESPAK) as their local consultants on October 29, 1984. NESPAK commenced their activities in November 1984.

20. The consultants were of considerable assistance to WAPDA in project implementation.

4. Procurement of Goods and Services

21. The procurement of foreign sourced goods and services was conducted in compliance with the Bank's and USAID's guidelines as applicable. Locally sourced goods and services were procured in accordance with WAPDA's standard practices.

22. It became evident in mid-1985 that Mari-Guddu gas pipeline and gas mixing station would not be available to support the initial start-up of the first two (2) gas turbines. This necessitated the procurement of some equipment that was not included in the main turnkey packages. A standby pressure reducing station and other valving and piping material were purchased in order to enable gas turbine units 1 and 2 to be started-up on Sui gas. Both the Bank and USAID financed the purchase of this equipment.

5. Conditions and Covenants

23. WAPDA has demonstrated its efficiency by complying with all the covenants of the loan. WAPDA also satisfactorily accomplished those measures necessary to ensure smooth implementation of the project. A

summary of WAPDA's compliance with the loan covenants is given in Appendix 7.

24. The conditions of loan effectiveness were met 309 days after the signing of the loan which became effective on November 2, 1984.

6. Project Schedule

25. A comparison between the appraisal schedule and actual performance has already been discussed earlier in this report. Table 4 quantifies the delays in completion with reference to the schedule presented in the appraisal report.

TABLE 4
Project Implementation Key Dates
(Target Vs Actual)

Description		Bids Issue	Contract Award	Commissioning
GAS TURBINES	Target	July 1983	January 1984	November 1985
	Actual	July 1983	September 1984	March 1986
	Delay	0	8 months	4 months
STEAM TURBINES	Target	March 1984	August 1984	January 1987
	Actual	August 1984	March 1986	August 1988
	Delay	5 months	19 months	19 months
GAS PIPELINE	Target	January 1984	July 1984	June 1985
	Actual	October 1984	April 1985	June 1986
	Delay	9 months	9 months	12 months
TRANSFORMERS AND SWITCHYARD	Target	July 1983	July 1984	June 1985
	Actual	July 1983	April 1985	February 1986
	Delay	0	6 months	5 months

7. Disbursements

26. No amount has yet been cancelled from the loan proceeds as a result of cost underrun. However approximately $28 million is considered surplus and may be cancelled by the Bank.

27. The loan closing date originally set for August 31, 1987 has already been extended to August 31, 1989. WAPDA is in the process of requesting the Bank for another extension to August 31, 1991.

28. As of February 28, 1989, an amount of $47.31 million has been disbursed from loan No. 0661-PAK leaving a balance of $10.19 million. Also an amount of $71.29 million has been disbursed from loan No. 0660-PAK(SF) leaving a balance of $28.52 million.

29. It should be noted that Loan 0660-PAK(SF) was for SDR 78,733,000, which at the time of loan signature was equivalent to $83.4 million. Due to the change in the parities of various international currencies, the equivalent of SDR 78,733,000 is now $99.81 million, which partially accounts for the difference in the increased balance for Loan No. 0660-PAK(SF). Another reason was the non utilization of approximately $10 million reserved for the unallocated loans. Appendix 8 shows the disbursement schedule compared with actual disbursement.

C. Initial Operation

30. The project has been operating successfully since commissioning. Some problems were encountered as summarized below:

i. Lots 1A and 1B: Gas Turbine-Generators

Significant problems encountered during commissioning included the "SSS" clutch system (which is required for synchronous condenser operation), whereby pawls and rachets were broken; gas turbine hot gas path problems, whereby transition pieces and combustion liners were damaged. The pony motors for synchronous condenser operation and torque converters were found to be undersized and the 6.6 kV bus transfer scheme for the auxiliary power supply was also modified to meet the customer's requirements.

GE replaced the clutch pawl and rachet assemblies in all units. The system has since operated satisfactorily. Combustion liners and transition pieces were also replaced with modified liners and transition pieces. The pony motors were replaced with motors of higher rating. Some modifications were carried out by GE on the bearing lift oil system for the synchronous condenser. Also, torque converters were replaced with units of higher rating. The 6.6 KV auto bus transfer scheme was also modified by GE. All of the above modifications were carried out at no cost to WAPDA.

ii. Lot 4: HRSG's, Steam T-G's and BOP

GE started construction at the site in June 1986. By the end of 1986, it became apparent that the schedule had already slipped. Estimated site progress at the end of the year was 15 percent against the approximately 40 percent required to meet the schedule. Much of this delay was attributed to the non-availability of equipment and material at the site. Although the pace of material deliveries increased during 1987, and by March over 40 percent completion had been achieved, progress remained below the required level.

Workaround schemes were developed whereby only essential systems would be completed, so that the units could be synchronized at the earliest possible date with the remaining works to be completed after the plant started generating power. As a result, even though the machines started generating power in December 1987 and March 1988, much work remained to be done throughout 1988. As of April 1989 outstanding work is mostly confined to "punch list" items and the DATATRONICS Control System.

During commissioning of the plant, problems were encountered with condensate/feedwater pumps, HRSG tube sheet distortion and bypass damper leakage. This latter also affected the output of the

plant. The damper leakage problem and the HRSG tube sheet distortion problems were corrected. GE has made recommendations regarding the condensate/feedwater pump problems.

iii. Measures taken to ensure continued smooth operation of the project.

In order to ensure the continued smooth operation of the Combined Cycle Plant the following measures were taken:

a) Gas turbine hot gas path: During the initial operation of the gas turbines, problems were noticed in the hot gas path components. These problems were overcome by General Electric's implementation of a part modification and replacement program. A GE Resident Engineer remained on site during the entire period to rectify the problems and keep the machines running.

b) Fuel Gas Supply:

A fuel gas supply study team consisting of WAPDA, General Electric and Gibbs & Hill representatives and an independent consultant was formed to evaluate the deleterious effects of liquids in the gas fuel on gas turbine availability and reliability. The team's charter was to recommend the remedial measures to be taken. The team established that the liquid hydrocarbon problem was associated primarily with the Sui gas. They recommended that the Sui gas should not be used in the gas turbines until new filters and other equipment are installed at Guddu. The team members further recommended the addition of new filters and a scrubber at the Mari field and the addition of gas heaters and a scrubber after the mixing station at Guddu. The purpose of the heater is to vaporize the liquid hydrocarbon mist in the gas. Procurement of additional equipment is underway.

c) Training of Personnel

In order to familiarize WAPDA personnel with the plant systems and equipment, both hands-on and class room training were provided at site. Senior WAPDA engineers who attended this training are presently imparting the knowledge gained to their junior staff.

d) Supply of Spares

Spare parts are essential for smooth and continuous operation of the plant and the supply of spares was given top priority. WAPDA originally purchased only the essential spare parts, sufficient for first year's plant operation. However, additional orders were recently placed for 3-5 year and 10 year supply of spares.

e) Intake Structure:

Intake structure problems became apparent during last summer's floods which caused considerable damage to the intake structure equipment. A study team was formed with members from WAPDA, USAID, G&H and GE to investigate the sources of problems and recommend solutions.

The team's most significant conclusions were as follows:

1) The B-S Feeder canal should be restored to its original design bed level which presently is over 3 meters above the original bed level.

2) The road/rail bridge over the B-S Feeder canal, downstream of the plant should be expanded so that its flow constriction is removed and full discharge is passed without hindrance. This would reduce the build up of silt in the canal at the power station.

3) A head regulator should be constructed downstream of the road/rail bridge. This regulator in conjunction with the canal gates at the Indus river may be utilized to flush the silt from the canal periodically.

III. EVALUATION OF IMPLEMENTATION

A. Project Components

31. WAPDA's energy production in the past decade has been less than the maximum demand. The annual growth in energy sales has averaged 9 percent while the growth in maximum demand has been 12 percent. Augumentation of generating capacity through the addition of thermal plants, which take a shorter time to construct and bring into operation than hydroelectric units, was seen as part of the solution of this problem. Availability of thermal plants, which are not effected by water availability, is also greater than that for hydro units. Also the lead time required to bring gas turbine units into operation is relatively short.

32. The gas turbines have a total capacity of approximately 400 MW. With the addition of the heat recovery boilers and two steam turbine-generators, an additional 200 MW has been made available in a relatively short period of time. The operation of the steam turbines does not require any additional fuel over and above that required for the gas turbines. The combined cycle mode of operation is much preferred over the single cycle mode of operation because it is more efficient.

33. In the combined cycle mode the plant can yield thermal efficiency of around 45 percent compared with only 30 percent for simple cycle gas turbines and 36 percent for steam turbines.

B. Project Cost

34. The actual cost of the project was $254.7 million, which is 29.7 percent below the estimated cost of $362.2 million. A detailed comparison of the appraisal estimates and actual and estimated costs is given in Appendix 5.

45

35. The substantial cost underrun which was achieved is attributed to the lower than anticipated prices for the gas turbines, combined cycle add-on, switchyard extension and gas pipeline materials and equipment contracts. It should be noted that both the power plant and oil and gas equipment industries were in a depressed state during the periods over which the equipment was purchased. This resulted in extremely competitive bidding situations.

C. Project Schedule

36. The gas turbine-generators were commissioned four (4) months late compared to the project appraisal schedule. The delay in completion is attributed to the fact that gas turbine plant Lot 1A and 1B contracts were awarded eight (8) months later than the appraisal schedule, although tenders were submitted in October 1983 as originally planned. The three (3) month schedule for bid evaluation and contract negotiations indicated on the original schedule was not realistic however. The fact that the engineer was not brought on board until November 1983 and the fact that there were extensive negotiations between WAPDA and General Electric Company, the selected equipment supplier, also contributed in some measure to the delay. Nevertheless, both gas turbine-generator installations were completed within shorter time spans than provided for in the original schedule and the last unit was taken over only four months later than originally planned.

37. The steam turbine-generators were commissioned 19 months later than the appraisal schedule. The reasons for this delay were as follows:

38. The contract for the Lot 4 Combined Cycle add-on of HRSG's, steam turbines, balance of plant and auxiliaries was awarded in mid-March 1986, over 19 months behind the appraisal schedule. There were several reasons for this delay. The original pre-award schedule was too ambitious allowing only four months for preparation of the tender documents (with preparation being started in October 1983, which was before the engineer started his work), three and one-half months for the bidding process and two months for the evaluation of proposals. In actual fact the bidding

documents were issued on August 1, 1984 which was five months behind the appraisal schedule. The bidding and evaluation process turned out to be complex and time consuming for a number of reasons, including the following:

- two envelope (technical and pricing) bidding
- the Lot 4 and the Lot 4A plus Lot 4B breakdowns for proposals
- the large number of bidders and proposals
- difficulties in determining the substansive responsiveness of certain bidders (particularly in the area of satisfying experience criteria)
- objections to the bidding and evaluation process raised by certain bidders (which had to be responded to, despite the fact that such objections were without basis)
- extensive and time consuming negotiations with GE, the lowest evaluated bidder

39. The Lot 4 contract was finally awarded in mid-March 1986 which was 19 months later than appraisal schedule. At the time of award it appeared that part of the delay already incurred would be recovered, since the Lot 4 contractor, the General Electric Company, had proposed a 21 month schedule from award to Taking Over as compared with the 29 months envisaged in the appraisal implementation plan. The Lot 4 Units 1 and 2 began to generate electricity in December 1987 and March 1988 respectively which was approximately 14 months behind the appraisal schedule. Taking Over of Unit 1 was finally accomplished in November 1988 and of Unit 2 in August 1988. This represented a 22 months slippage with respect to the appraisal schedule. The reasons for the delays in taking over are discussed elsewhere in this report. However, it should be noted that significant quantities of electricity were produced during the period between initial power production and Taking Over of the units.

Two other contracts were significant from the power generation standpoint. The Lot 2 switchyard extension and step-up transformers were first placed into service during November, 1985 and supported the initial start-up of the gas turbines. The Lot 6A/6B Mari gas pipeline was completed a little later than planned, in February, 1986. As explained earlier a tie-in to the Sui gas pipeline enabled the first two gas turbines to be placed in operation on Sui gas rather than Mari gas as originally planned.

40. Two major contracts undertaken by Pakistani contractors have fallen seriously behind schedule. The contract for the Central Control Building was awarded in April, 1985 to MLC with a completion date of March 1986. As of the date of this report the Central Control Building, although almost complete, has not yet been taken over by WAPDA and the contractor is therefore three years behind schedule. Fortunately the gas turbines were provided with local controls and the delay in installing the gas turbine remote control panels in the central control room did not prevent or curtail the generation of electrical power. Ad hoc measures have been undertaken since early 1986 to compensate for the unavailability or limited availability of the central control building. The second local contract to fall substantially behind schedule was the one for the fuel oil storage tanks. The contract was awarded in April 1985 to KSEW with a completion date in March 1986. The three oil tanks were only completed in January of this year. Liquidated damages have been imposed on both contractors because of the unexcusable delays in contract completion.

D. Engagement of Consultants and Procurement of Goods and Services

41. Gibbs & Hill Inc., of U.S.A. were appointed as consultants for this project under USAID financing. WAPDA appointed National Engineering Services of Pakistan (NESPAK) as local consultants.

42. Procurement of goods financed by the Bank was undertaken in accordance with the Bank's Guidelines for procurement. No serious procurement problems were encountered during implementation of the project.

E. Performance of Consultants, Contractors and Suppliers

43. The overall performance of consultants, contractors and suppliers was satisfactory except for the performance of the local contractors who were responsible for the Central Control Building and the Fuel Oil Storage Tanks.

F. Conditions of the Loan Covenants

The loan agreement became effective on November 2, 1984, which was 309 days later than the date stipulated with the loan agreement. The delay was caused due to delayed compliance in one of the conditions of loan effectiveness in which WAPDA was to have a gas supply contract signed between WAPDA and the operators of the Mari gas field.

All the covenants specified in the loan documents have been complied with. Please see Appendix 7.

G. Disbursements

44. The original closing date of the loan was August 31, 1987, but was extended to August 31, 1989. An extension was necessary to account for the late award of contract. WAPDA is requesting another extension in loan closing date to finalize settlement of outstanding retention monies.

H. Environmental Impact

45. No significant adverse impact has been made on the environment of the Guddu area by this project. Gas turbine plants have inherently fewer adverse environmental impacts than other types of power plants. For the combined cycle steam plants the potentially significant problems are noise and gas emissions particularly nitrogen oxides. The major environmental issues are thermal discharge in cooling water and liquid waste such as boiler blowdown or the discharge of waste from the plant.

The following brief discussion addresses each of the concern:

1. Air Quality

KBN Engineering & Applied Sciences Inc. of U.S.A. conducted an environmental assessment of the project. Result of their measurement of air quality are shown in table 5. The concentrations represent the predicted impact due to the combined effect of all existing sources at WAPDA facility for the 1985 mateorological data base. Each of the concentrations is well below the applicable World Bank's Air Quality Guidelines.

TABLE 5
Maximum Ambient Concentration Due All Existing Sources
At 450 MW Combined Cycle Project

Pollutant	Averaging Time	Maximum Predicted Concentration (ug/m^3)	World Bank (ug/m^3)
Natural Gas			
Sulphur Dioxide	24-Hours	23	500
	Annual	4	100
Nitrogen Dioxide	Annual	12	100
Oil*			
Sulphur Dioxide	24-Hours	325	500
	Annual	54	100
Particulate Matter+	24-Hours	23	500
	Annual	3.8	100
Nitrogen Dioxide	Annual	15	100

* Only used during natural gas curtailments which primarily occur during the winter months of December and January.

+ Background concentration for particulate matter is 200 ug/m^3.

ii. Noise

Noise measurements of specific noise sources within the existing power plant complex were made. Measurements of noise sources were made at specific locations inside buildings, to monitor worker exposure, and outdoors, to monitor both worker exposure and outdoor sound power levels. The outdoor sound power levels were used to assess the effects of noise sources on community sound levels.

The majority of the measurements were made at a distance of 1.5 meters from the source. Additional measurements were obtained at intermediate locations between two or more noise sources, the purpose being to measure sound levels to which workers are routinely exposed. The results of the survey are presented in Table 6. The greatest sound levels are in the 125 Hz frequency band, where the noise level was measured at 92 to 97 dB. The World Bank in its Occupational Safety and Health Guidelines recommended that workers not be exposed to noise levels in excess of 90 dBA. The results indicate that noise level do not present any significant hazard in most plant areas.

TABLE 6
Results of Survey of Noise Sources at
Guddu 450 MW Combined Cycle Project

Noise Source	Distance from Source (Meters)	Noise Levels (dBA)
450/600 MW Combined Cycle Plant		
Unit No. 4 Power Block	1.5	84
Unit No. 4 HRSG	1.5	80
Between Unit No. 3 and Unit No. 4 HRSGs, 10 ft. from Unit No. 4 HRSG	3	84
Unit No. 4 Gas Turbine Exhaust Duct	1.5	98
Unit No. 4 Gas Turbine Exhaust Duct		
- Unit No. 3 Side	1.5	102
Between Units No. 3 & 4 Gas Turbines	9	92
Between Units No. 3 & 4 Gas Turbines		
- Filter House End	9	85
Steam Turbine Building	1.5	79
Inside Turbine Building		
- Boiler Feed Pumps	1.5	93
- Hydraulic Unit	1.5	89
- Turbine (2nd Floor)	1.5	92
- Turbine Room (3rd Floor)	1.5	94
Control Building		
- Invertor Room (Invertor)	1.5	80
Pumphouse		
- Inside	1.5	89
- Outside	1.5	79

52

Special survey of noise levels associated with the Combined Cycle Power Plant was undertaken. This survey was performed in response to concern by staff personnel over a cyclic, resonating noise, apparent at high load levels, originating from the HRSGs. Several measurements were obtained at various distances from the HRSGs, including inside the Gibbs & Hill site construction offices. Frequency measurements were also obtained.

Results of the survey are given in Table 7:

TABLE 7
Results of Special Noise Survey of 450/600 MW
Combined Cycle Plant HRSGs

Source/Location	Noise Level, dB								
	A Scale	Frequency (Hz)							
		63	125	250	500	1K	2K	4K	8K
G&H Site Construction Office									
1) Inside conference room at a table	57-64	65-74	74-82	55-59	51-54	39-43	34-36	32-34	
2) At window	72-77	82-87	92-96	66-69	51-55	45-47	41-44	41-43	30
3) Outside adjacent to building	74-78								
Midway Between Office and Unit No. 4	77-81								
Adjacent to Unit No. 4 Gas Turbine	84	81-84	88-91	75-79	73-76	75-76	77	79	62
Adjacent to Unit No. 4 HRSG	80	87-90	92-97	74-77	70-72	70-73	69-71	69-71	57

iii. Water/Wastewater Discharges

Wastewater discharge rates for the existing steam power units and the combined cycle units is presented in table 8:

TABLE 8
Summary of Existing Industrial and
Associated Sanitary Wastewater Discharges

Water Use	Maximum Wastewater Discharges (meter³/min) Thermal Units #1 & # 2	Thermal Unit #3	Thermal Unit #4	450 MW GT/HRSG	Total
ONCE THROUGH COOLING OPERATIONAL SCENARIO					
Once Through Circulating Cooling Water Discharge	618	450	460	916	2,444
Low Volume Wastes	30.0	10.0	10.0	11.4	61.4
Subtotal - Industrial Discharges	648	460	470	927	2,505
Plant and Colony Sanitary Wastewater					3.7
Total Existing Station Wastewater Discharge with Once Through Cooling Operations					2,509
COOLING TOWER OPERATIONAL SCENARIO					
Cooling Tower Blowdown	1.9	1.4	1.4	2.7	7.3
Low Volume Wastes	30.0	10.0	10.0	11.4	61.4
Subtotal - Industrial Discharges	31.9	11.4	11.4	14.1	68.7
Plant and Colony Sanitary Wastewater					3.7
Total Existing Station Wastewater Discharge with Once Through Cooling Operations					72.4

Note: 1. Low volume wastes estimated as 50 percent of the total plant service water.
2. Colony wastewater estimated as 66 percent of the total colony and plant potable water.
3. Cooling tower blowdown calculated based on 5 cycles of concentration and blowdown volume equals 25 percent of tower evaporative losses; therefore, blowdown volume will be 20 percent of tower makeup volume.

54

46. Combined cycle units discharge heated once through cooling water downstream of the Guddu Barrage. Discharge is via a canal to the Indus River. All units discharge low volume plant wastewater and sanitary waste water to the Indus river below the barrage. A sedimentation basin which has been constructed for the combined cycle plant is used for treatment of any low volume waste generated by the units prior to discharge. No water quality problems have been reported or observed.

I. Project Benefit

47. WAPDA has continued to expand its power generation and transmission system. Addition of 450 MW Combined Cycle Project was a part of 4,000 MW of generating capacity to total upto 8,094 MW by the year 1990.

48. At the time of appraisal, WAPDA's total installed generating capacity was 2,990 MW. It was projected that by the end of FY 1988/89 the total installed capacity would be 5,419 MW. Installed generating capacity, peak and energy generation by the end of FY 1988/1989 are shown in appendix 14.

49. Other direct and local benefits derived from the installation of Guddu 450 MW Combined Cycle Project are:

a) Job opportunities in various categories have been created. These opportunities have been offered to the people domiciled in the Provice of Sind. About 400 including engineers, technician, skilled and unskilled workers have already been employed at this project.

b) The operation of the plant has contributed to relief from load shedding.

c) This plant, the first combined cycle plant in Pakistan, has exposed WAPDA to a new technology. The experience and lessons learned will be of great use in the development of the additional combined cycle plants that are planned.

55

J. Performance of Borrower and Executing Agency

50. The performance of WAPDA (see appendix 12) as executing agency in developing the energy requirement of Pakistan has been excellent. Significant progress has been achieved in thermal power development, energy conservation and in use of indigenous fuel resource. WAPDA's financial performance as summarized in the table below, is generally satisfactory.

(WAPDA to provide table and comments)

K. Performance of the Bank

51. The project was selected in line with the overall development strategies and priorities of the Government, and was carefully formulated, based on the feasibility study prepared by the consultants and WAPDA. The objectives of the project, such as developing combined cycle plant to achieve more efficient use of energy, and improve much needed power supply in Pakistan were in accordance with the appraisal schemes.

52. The Bank's decision to let WAPDA use the services of the consultants was correct and greatly contributed to the successful implementation of the project. Actions taken by the Bank were timely and adequate. Bank staff spent a total of * mandays in the field for the purpose of assisting project implementation.

* ADB to provide the total number of mandays.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

53. Cost underrun on this project was nearly 30 percent (see page 24). It must be recognized, however, that costs cannot normally be estimated with certainty, especially over long lead times. Discrepencies between appraisal estimates and actual costs could be reduced if contracts for the main equipment were firmed up before loan negotiations, or if contracts were awarded soon after loans become effective. Every effort should be made by the executing agency to comply with the covenants of the loan agreement within periods stipulated in the contract for the loan effectiveness.

54. The project has remained viable as envisaged during appraisal and has substantially provided the originally assumed economic and social benefits. WAPDA has gained extensive experience in the development and operation of combined cycle power generation facilities.

B. Recommendations

55. (to be prepared by the Bank)

APPENDIX 1

CHRONOLOGY OF EVENTS IN THE HISTORY OF PROJECT

CHRONOLOGY OF EVENTS IN THE HISTORY OF PROJECT

1982

January 21, 1982	Local Consultants NESPAK Lahore were engaged to study and prepare the feasibility report of proposed 450 MW Combined Cycle Power Plant at Guddu

1983

March 6, 1983	NESPAK submitted feasibility report to WAPDA.
April 19-27, 1983	Asian Development Bank Appraisal Mission visited Pakistan in connection with appraisal of proposed 450 MW Combined Cycle Power Plant Guddu.
April 27, 1983	Memorandum of Understanding signed between Islamic Republic of Pakistan and Asian Development Bank Manila Phillipines.
May 24, 1983	Stone & Webster USA prepared the Tender Documents and submitted to WAPDA.
July 16, 1983	Tenders invited for four Gas Turbine Generator sets and 220 KV Switchyard Extention equipments.
October 31, 1983	Tenders received and opened for four Gas Turbines Generator sets.
November 1, 1983	Tenders received and opened for 220 KV Switchyard Extension equipment.
December 29, 1983	ADB Loan 661-PAK and 660-PAK (SF) signed between Islamic Republic of Pakistan and Asian Development Bank.

1984

June 28, 1984	Contract awarded for Lots 1A and 1B - Gas Turbine Generators and Accessories.
July 25, 1984	Contract signed between WAPDA and ICC for Lot 2 - Main Step-up Transformer and 220 KV Switchyard Extension Work.
September 26, 1984	Contract signed between WAPDA and GE for Lots 1A and 1B.

CHRONOLOGY OF EVENTS IN THE HISTORY OF PROJECT

1985

April 4, 1985	Contract awarded for the Supply of Gas Pipeline Material to several suppliers.
April 14, 1985	Contract signed between WAPDA and Petrocon Ltd. for the Construction of Mai-Guddu Gas Pipeline.
April 30, 1985	Contract awarded to KSEW for the construction of High Speed Diesel Fuel Oil Tanks.
November 28, 1985	Gas Turbine Generator Unit 1 started Initial Operation.
December 20, 1985	Erection and Commissioning of Switchyard Extension completed.
December 27, 1985	Gas Turbine Generator Unit 2 started Initial Operation.

1986

February 23, 1986	Gas Pipeline construction completed.
March 04, 1986	Gas Turbine Generator Unit 3 started Initial Operation.
March 12, 1986	Gas Turbine Generator Unit 4 started Initial Operation.
March 16, 1986	Contract awarded to GE for Lot 4 - STAG Units add-on.
April 26, 1986	Prime Minister of Pakistan inaugurated Phase I of the Project.

1987

February 10, 1987	Contract signed between WAPDA and GE for Lot 5C - Central Chilling and Heating Plant.
December 27, 1987	STAG Unit 1 started Initial Operation.

1988

March 22, 1988	STAG Unit 2 started Initial Operation.
May 21, 1988	Central Chilling and Heating Plant taken over by WAPDA.
August 21, 1988	STAG Unit 2 taken over by WAPDA.
November 19, 1988	STAG Unit 1 taken over by WAPDA.

APPENDIX 2

DETAILED DESCRIPTION OF PROJECT SCOPE

DETAILED DESCRIPTION OF PROJECT COMPONENTS
(As Envisaged at appraisal)

The project envisaged the construction of a 450 MW Combined Cycle Power plant at the Guddu Thermal Power Station. It was intended that four gas turbines would generate 300 MW and that two steam turbines would generate 150 MW of power. Specifically the scope of the project will comprise of the following:

a) Four (4) Units of 100 MW nominal rating gas turbines and generators (derated to 75 MW at site conditions) complete with auxiliaries and local panels.

b) Four (4) Units of Heat Recovery Boilers complete with auxiliaries.

c) Two (2) Units of 75 MW steam turbines and generators complete with auxiliaries.

d) One (1) Central Control and Data Logging facility.

e) Step-up and Service Transformers, Switchgears and associated electrical equipment for the transport of power from the power plant to the electrical grid.

f) Gas dehydration facilities and approximately 60 km of 22" diameter gas pipeline for the treatment and transportation of gas from the Mari gas field to the power plant.

g) Associate civil works.

h) Provision of Staff Training.

i) Provision of Consulting Services.

The plant would be arranged in two discrete streams, each stream comprising of two (2) gas turbines whose exhaust gases would flow into two (2) heat recovery boilers which, in turn, would produce steam for operation of a steam turbine-generator.

APPENDIX 3

BREAKDOWN OF TURNKEY PACKAGES (LOTS)

GUDDU 450/600 MW COMBINED CYCLE POWER PLANT

BREAKDOWN OF TURNKEY PACKAGES (LOTS)

Lot No.	Description	Financing Agency Foreign Currency	Financing Agency Local Currency	Contractor
1A	Two gas turbine-generators and auxiliary equipment	USAID	GOP (WAPDA)	General Electric Company (U.S.A.)
1B	Two gas turbine-generators and auxiliary equipment	ADB	GOP (WAPDA)	General Electric Company (U.S.A.)
1B-A	Fuel oil treatment plant	ADB	GOP (WAPDA)	General Electric Company (U.S.A.)
2	220 kV switchyard extension and step-up transformers	ADB	GOP (WAPDA)	Imperial Construction Company (Pakistan)
3	Civil works and structures			
	. Central control building	n/a	GOP (WAPDA)	McDonald Layton & Co. (Pakistan)
	. Administration building, warehouse and workshop	n/a	GOP (WAPDA)	Habib Rafique Ltd (Pakistan)
	. Chiller plant building	n/a	GOP (WAPDA)	Zafar Brothers
	. Fuel oil storage tanks	n/a	GOP (WAPDA)	Karachi Shipyard & Engineering Works Ltd (Pakistan)
	. Fuel oil receiving tanks	n/a	GOP (WAPDA)	Erection Engineers & Contractors (Pakistan)
	. Miscellaneous	n/a	GOP (WAPDA)	Various local contractors
3A	Fire protection system	n/a	GOP (WAPDA)	Al-Tariq Traders (Pakistan)
4	Four HRSG's, two steam turbine-generators, balance of plant and auxiliaries	ADB	GOP (WAPDA)	General Electric Company (U.S.A.)
5C	Heating and chilling plant	USAID	GOP (WAPDA)	General Electric Company (U.S.A.)
6A	Package I and II for supply of pipe and fitting	ADB	n/a	Daito Corporation (Japan)

GUDDU 450/600 MW COMBINED CYCLE POWER PLANT

BREAKDOWN OF TURNKEY PACKAGES (LOTS)

Lot No.	Description	Financing Agency		Contractor
		Foreign Currency	Local Currency	
6A	Package III, V and VI for supply of valves and supply and erection of gas mixing station and dehydrator	ADB	GOP (WAPDA)	Siirtec S.p.A. (Italy)
6A	Package IV for supply of pipe coating materials	ADB	n/a	Caroplast Fritz Muller (West Germany)
6A	Package VII for supply of Cathodic protection materials	ADB	n/a	Phoceenne de Metallurgie (France)
6A-1	Standby Sui gas reducing	n/a	GOP (WAPDA)	Petrocon Ltd (Pakistan)
6B	Gas pipeline installation	ADB	GOP (WAPDA)	Petrocon Ltd (Pakistan)
-	Fuel gas heaters	n/a	GOP (WAPDA)	Mono Impex (Pvt) Ltd (Pakistan)
-	Steam & condensate piping for chiller plant	n/a	GOP (WAPDA)	Mono Impex (Pvt) Ltd (Pakistan)
-	Steam & condensate piping for fuel gas heaters	n/a	GOP (WAPDA)	Fair Field (Pakistan)
-	HSD oil decanting system and tank interconnection piping	n/a	GOP (WAPDA)	Erection Engineers & Contractors (Pakistan)
-	Miscellaneous mechanical piping systems	n/a	GOP (WAPDA)	Fair Field (Pakistan)
-	Temporary fire protection system	n/a	GOP (WAPDA)	Erection Engineers & Contractors (Pakistan)
-	Supply and installation of cooling water piping to the gas turbine heat exchangers	n/a	GOP (WAPDA)	Petrocon Ltd (Pakistan)
-	Cooling water supply and return piping for chiller plant	n/a	GOP (WAPDA)	Al-Hamra Trading Co. (Pakistan)
-	Installation and tie-in of PECO filters	n/a	GOP (WAPDA)	Procon Ltd (Pakistan)

APPENDIX 4

MAJOR CONTRACTS AND ACTUAL COSTS

22-Apr-89

MAJOR CONTRACTS AND ACTUAL COSTS
($ Million)

LOT	DESCRIPTION	Total	USAID	ADB		GOP	REFERENCE
			LOAN = 391-0473	LOAN = 0661-PAK	LOAN = 0660-PAK(SF)		
1A	Two Gas Turbines Generators and Acessory Equipment	43.23	41.61			1.62	Contract Amount + Variation Orders
1B	Two Gas Turbines Generators and Acessory Equipment	41.05		39.68		1.37	Contract Amount + Variation Orders
1B-A	Fuel Oil Treatment System	0.96		0.89		0.07	Contract Amount
2	Main Step-up Transformers and Switchyard Extension	6.56		4.62		1.94	Contract Amount + Variation Orders
3	Civil & Structures	6.97				6.97	Contract Amount
4	Steam Turbines, HRSG'S and Balance of Plant	71.99			63.20	8.79	Contract Amount + Variation Orders
5C	Chiller Plant	1.42	0.47			0.95	Contract Amount + Variation Orders
6A	Gas Pipe Line Material	4.52			4.35	0.17	Contract Amount + Variation Orders
6A-1	Standby Sui Gas Pressure Reducing Station & Piping	3.61	0.17			3.44	Purchase Order Amounts
6B	Gas Pipe Line Construction	3.67				3.67	Contract Amount + Variation Orders
	Miscellaneous gas pipeline equipment (gas heaters, filter-separators, scrubbers, valves etc.)	1.78		1.52		0.26	Contract Amount
	T O T A L S :	185.76	42.25	46.71	67.55	29.25	
	Financing Ratio (%)		22.74	25.15	36.36	15.75	

APPENDIX 5

COMPARISON BETWEEN ACTUAL EXPENDITURE
AND
APPRAISAL COST ESTIMATE

(Need WAPDA input)

VS. APPRAISAL COST ESTIMATE
($ Million)

LOT	DESCRIPTION	FOREIGN CURRENCY		LOCAL CURRENCY		TOTAL		REMARKS
		Appraisal	Actual	Appraisal	Actual	Appraisal	Actual	
1A	Two Gas Turbines Generators and Acessory Equipment	77.60	41.61	3.30	1.62	80.90	43.23	
1B	Two Gas Turbines Generators and Acessory Equipment		39.68		1.37		41.05	
1B-A	Fuel Oil Treatment System		0.89		0.07		0.96	Not considered at appraisal
2	Main Step-up Transformers and 220 KV Switchyard Extension	10.30	4.62	1.10	1.94	11.40	6.56	
3	Civil and Structures			19.50	6.97	19.50	6.97	Appraisal estimate included some civil works subsequently include in other lots
4	Steam Turbines, HRSG's and Balance of Plants	65.40	63.20	12.40	8.79	77.80	71.99	Appraisal estimate excluded civil work
5	Central Controls	2.30		0.30		2.60	0.00	Included in appraisal estimate but subsequently droped
5c	Chiller Plant		0.47		0.95	0.00	1.42	Not separately identified at appraisal
6	Gas Pipe Line	6.00	4.35	4.20	3.84	10.20	8.19	
6A-1	Standby Sui Gas Pressure Reducing Station and Piping		0.17		3.44	0.00	3.61	Not considered at appraisal
	Miscellaneous gas pipeline equipment (gas heaters, filter separators, scrubbers, valves etc.)		1.52		0.26	0.00	1.78	Not considered at appraisal
	Cost of Engineering Services	3.70	14.56	0.30	1.37	4.00	15.93	
	Sub Total Project Base Cost	165.30	171.07	41.10	30.82	206.40	201.89	
	Import Duties and Taxes			74.40	32.64	74.40	32.64	
	Contingencies	8.00		2.10	1.42	10.10	1.42	
	Escalation in Cost	19.60		9.20		28.80	0.00	
	Interest During Construction	14.00	17.53	28.50	1.44	42.50	18.97	
	Total Project Base Cost	206.90	188.60	155.30	66.12	362.20	254.72	

APPENDIX 6

SCOPE OF ENGINEERING/CONSULTANT'S SERVICES

SCOPE OF ENGINEER'S SERVICES

ope of Work

e Consultants were to have overall responsibility for supervision and plementation of the Guddu Combined Cycle Power Plant Project and were to be sisted by local Consultants appointed by WAPDA. The Consultants were to ovide technical assistance on various matters as and when required by PDA, USAID and all other Consultants/Contractors involved in the project. his scope of work did not include evaluation of the bid for Lot 1B).

ecific areas of activities in which the Consultants were required to assist PDA included but were not limited to the following:

1. Preliminary Design

   a. To study and become familiar with the already completed bid documents for Lot 1A, Lot 1B and Lot 2.

   b. To study and review the specifications and design drawings for Lot 3 (i.e. Civil and Structural Works) prepared by the local Consultants and coordinate with them on modifications, if necessary.

   c. To acquire all necessary information including that from activit and b. above, and to prepare detailed specifications and l. schemes for Lot 4A, 4B and 6A.

   d. To receive and monitor services from and assist the local Consultants in carrying out their assignment according to the specified scope of work and ensure that they perform services in accordance with the appropriate technology and standards.

   e. To prepare a detailed project implementation schedule, reflecting manpower and budgetary needs and establishing target dates for all activities such as issuance of bid documents, evaluation of bids, award of contracts, and other activities relating to construction, commissioning and taking over of the plant.

2. Bid Documents

   a. To prepare draft bid documents for Lots 4A, 4B, 5 and 6A (including gas mixing station and dehydration plant) for approval by WAPDA, USAID and ADB.

   b. After approval by WAPDA, USAID and ADB, to prepare and print the requisite number of final bid documents.

c. To assist WAPDA in pre-qualification of prospective bidders, issue bid documents and to answer queries as they pertained to the above in consultation with WAPDA, if required.

3. Bid Evaluation and Recommendation for Award

a. To Scrutinize all bids received for all lots except 10, as to their:

i. Appropriateness and completeness;
ii. Comparative prices; and,
iii. Deviations from specifications.

b. To make recommendations to WAPDA, USAID and ADB for short listing of bidders on the basis of initial scrutiny.

c. To convene meetings with short-listed bidders along with WAPDA's representatives for clarification/confirmation of bids.

d. To evaluate the short-listed bids, in detail.

e. To evaluate the performance and productivity of the equipment on present worth basis.

f. To prepare draft bid evaluation reports for discussion with WAPDA, USAID and ADB.

g. To prepare and submit 20 copies of final evaluation report to WAPDA and 10 copies each to USAID and ADB with recommendations for the award.

h. To prepare draft Notice of Award documents and submit to WAPDA, USAID and ADB.

i. After approval of draft, to prepare Final Notice of Award/Contract documents for signature of WAPDA and the Contractors.

4. Supervision of Civil Works Construction

a. General supervision of all activities of the local Consultants/Contractors engaged by WAPDA for the civil works and structures such as sub-soil investigation, design of piling, estimates of civil works, execution of civil works including machine foundations, etc.

b. Coordinate design/construction information with various contractors for different parts of the project including scheduling and obtaining construction requirement needs to meet target dates.

c. Review and approve civil contractor's drawings for concrete pouring, steel placing, conduit and other wires, ducts and water sewer and other needs submitted through local consultants.

d. Review contractors' drawings, incorporating final design concept for issuance to contractor(s).

e. Coordinate contractor's construction schedules to ensure conformity with the project implementation target dates and provide guidance for sampling and testing procedures for adhering to specifications.

5. Monitor Equipment Manufacture

a. Review and approve shop drawings submitted by manufacturers of various equipment.

b. Monitor manufacture of plant and equipment at the factories to comply with the work schedule and contract specifications; submit progress reports to WAPDA, USAID and ADB; and, suggest measure for corrective action, if necessary, to remove bottlenecks.

c. Supervise trial runs and workshop tests of the equipment at the manufacturers' factories along with representatives of WAPDA and issue inspection certificates before shipment.

d. Review and approve specifications for crating and shipping of all equipment to comply with the requirements for sea/air transportation, local unloading, local transportation and erection conditions.

6. Erection of the Plant

a. Coordinate civil construction and erection schedules and per the project implementation schedule.

b. Supervise all erection works throughout the process of installation to ensure that the erection has been conducted in accordance with the approved drawings, and accepted erection practices and standards.

c. Take prompt action to reduce/eliminate any delays and reschedule activities to recover all lost time in the event of any unforeseen delay.

7. Start-Up

a. Prepare and coordinate program and procedures for pre-commissioning checks for the plant.

b. Prepare guideline procedures and schedules for commissioning the plant.

c. Coordinate all activities for start-up and supervise start-up and trial operation.

d. Prepare and coordinate test programs and approve procedures for all tests to be done at site for quality control of the plant.

e. Supervise initial commercial operation of the units according to the provisions of the contracts.

8. Acceptance

a. Check and approve final performance test procedures prepared by the Contractors.

b. Supervise final acceptance test and certify final acceptance test reports submitted by the Contractors.

c. Prepare appropriate acceptance certificates for joint signatures of WAPDA and the Consultants for issuance to the Contractors.

d. Assist WAPDA in taking over from the Contractors the units for commercial operation.

e. Check and approve as-built drawings and maintenance and operation manual to be submitted by the Contractors.

9. Direct Liability

a. Monitor defects in the plant during defect liability period and expedite rectification of the defects.

b. Supervise first inspection of the plant and equipment before expiry of the guarantee period; prepare report and suggest modifications, if required; and, provide specialist services if required by WAPDA.

10. Training

a. For Lots other than 1A (expenses to be borne by the manufacturers of equipment)

i. Prepare detailed training schedule for WAPDA's engineers for training in the manufacturers' factories and submit same to WAPDA and ADB for approval; and,

ii. Coordinate technical training with the manufacturers.

b. For Lot 1A (expenses to be financed by USAID through this contract

i. Prepare detailed training schedule for WAPDA's engineers for training in the manufacturers' factories and submit same to WAPDA and USAID for approval;

ii. Coordinate training program with the manufacturers; and,

iii. Arrange and pay for boarding, lodging, transportation within the United States, medical care/insurance, incidental expenses, etc. and obtain reimbursement from USAID.

c. On-the-Job Training

Coordinate on-the-job training arranged by the Contractors of WAPDA's engineers and technicians at the project site.

APPENDIX 7

COMPLIANCE WITH LOAN COVENANTS

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 660-PAK-(SF)

Executing Agency: Pakistan Water and Power Development Authority Lahore

Covenant		Status
1. 4.01	(a) The borrower shall cause WAPDA to carry out the project with due diligence and in conformity with sound administrative, financial, engineering and public-utility practices.	Complied with.
	(b) In the carrying out of the project and operation of the project facilities, the Borrower shall (i) procure, or cuase to be procured, the services of consultants in accordance with the provisions of Schedule 5 to this Loan Agreement, and (ii) perform, or cause to be performed, all obligations set forth in Schedule 6 to this Loan Agreement.	Complied with.
2. 4.02	The Borrower shall make available to WAPDA promptly as needed, and on terms and conditions acceptable to the Bank, the funds, facilities, services, lands and other resources which are required, in addition to the proceeds of the Loan and USAID Financing, for the carrying out of the Project and for the Operation and Maintenance of the Project facilities.	Complied with.
3. 4.03	The Borrower shall ensure that the activities of its department and agencies with respect to the carrying out of the Project and operation of the Project facilities are conducted and coordinated in accordance with sound administrative policies and procedures.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 660-PAK-(SF)

Executing Agency: Pakistan Water and Power Development Authority Lahore

Covenant			Status
4.	4.04	The borrower shall furnish, or cause to be furnished, to the Bank all such reports and information as the Bank shall reasonably request concerning (i) the loan, and the expenditure of the proceeds and maintenance of the service thereof; (ii) the goods and services financed out of the proceeds of the Loan; (iii) the Project; (iv) the administration, operation and financial condition of WAPDA; (v) financial and economical conditions in the territory of the Borrower and the international balance-of-payments position of the Borrower; and (vi) any other matters relating to the purposes of the loan.	Complied with.
5.	4.05	The Borrower shall enable the Banks representative to inspect the Project, the goods financed out of the proceeds of the Loan, and any relevant records and documents.	Complied with.
6	4.06	The Borrower shall take all action which shall be necessary on its part to enable WAPDA and shall not take or permit any action which would interface with the performance of such obligations.	Complied with.
7	4.07	(a) The Borrower shall exercise its rights under the Subsidiary Loan Agreement in such a manner as to protect the interests of the Borrower and the Bank and to accomplish the purposes of the Loan.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 660-PAK-(SF)

Executing Agency: Pakistan Water and Power Development Authority Lahore

	Covenant		Status
		(b) No rights or obligations under the Subsidiary Loan Agreement shall be assigned, amended abrogated or waived without the prior concurrence of the Bank.	Complied with.
8.	4.08	(a) It is the mutual intention of the Borrower and the Bank that no other external debt shall have any priority over the Loan by way of a lien on the assets of the Borrower. To that end, the Borrower undertakes (i) that, except as the Bank shall otherwise agree, if any lien shall be created on any assets of the Borrower as security for any external debt, such lien will ipso facto equally and ratably secure the payment of the Principal of, and service charge and any other charge on, the Loan; and (ii) that the Borrower, in creating or permitting the creation of any such lien, will make express provision to that effect.	Complied with.
		(b) The provisions of paragraph (a) of this Section shall not apply to (i) any lien created on property, at the time of purchase thereof, soley as security for payment of the purchase price of such property; or (ii) any lien arising in the ordinary course of banking transactions and securing a debt maturing not more than one year after its date.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 660-PAK-(SF)

Executing Agency: Pakistan Water and Power Development Authority Lahore

Covenant	Status
(c) The term "assets of the Borrower" as used in Paragraph (a) of this Section includes assets of any political subdivision or any agency of the Borrower and assets of any agency of any such political subdivision, including the State Bank of Pakistan and any other institution performing the functions of a central bank for the Borrower.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 661-PAK

Executing Agency: Pakistan Water and Power Development Authority Lahore

Covenant		Status
PARTICULAR COVENANTS		
1. 4.01	(a) The borrower shall cause WAPDA to carry out the project with due diligence and efficiency and in conformity with sound administrative, financial, engineering and public-utility practices.	Complied with.
	(b) In the carrying out of the project and operation of the project facilities, the Borrower shall (i) procure, or cause to be procured, the services of consultants in accordance with the provisions of Schedule 5 to the Special Operations Loan Agreement, and (ii) perform, or cause to be performed, all obligations set forth in Schedule 6 to the Special Operations Loan Agreement.	Complied with.
2. 4.02	The Borrower shall make available to WAPDA promptly as needed, and on terms and conditions acceptable to the Bank, the funds, facilities, services, lands and other resources which are required, in addition to the proceeds of the Loan and USAID Financing, for the carrying out of the Project and for the Operation and Maintenance of the Project facilities.	Complied with.
3. 4.03	The Borrower shall ensure that the activities of its department and agencies with respect to the carrying out of the Project and operation of the Project facilities are conducted and coordinated in accordance with sound administrative policies and procedures.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 661-PAK

Executing Agency: Pakistan Water and Power Development Authority Lahore

		Covenant	Status
PARTICULAR COVENANTS			
4.	4.04	The borrower shall furnish, or cause to be furnished, to the Bank all such reports and information as the Bank shall reasonably request concerning (i) the loan, and the expenditure of the proceeds and maintenance of the service thereof; (ii) the goods and services financed out of the proceeds of the Loan; (iii) the Project; (iv) the administration, operation and financial condition of WAPDA; (v) financial and economical conditions in the territory of the Borrower and the international balance-of-payments position of the Borrower; and (vi) any other matters relating to the purposes of the loan.	Complied with.
5.	4.05	The Borrower shall enable the Banks representative to inspect the Project, the goods financed out of the proceeds of the Loan, and any relevant records and documents.	Complied with.
6	4.06	The Borrower shall take all action which shall be necessary on its part to enable WAPDA to perform its obligations under the Project Agreement, and shall not take or permit any action which would interfere with the performance of such obligations.	Complied with.
7	4.07	(a) The Borrower shall exercise its rights under the Subsidiary Loan Agreement in such a manner as to protect the interests of the Borrower and the Bank and to accomplish the purposes of the Loan.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 661-PAK

Executing Agency: Pakistan Water and Power Development Authority Lahore

Covenant			Status
PARTICULAR COVENANTS			
	(b)	No rights or obligations under the Subsidiary Loan Agreement shall be assigned, amended abrogated or waived without the prior concurrence of the Bank.	Complied with.
8.	4.08	(a) It is the mutual intention of the Borrower and the Bank that no other external debt shall have any priority over the Loan by way of a lien on the assets of the Borrower. To that end, the Borrower undertakes (i) that, except as the Bank shall otherwise agree, if any lien shall be created on any assets of the Borrower as security for any external debt, such lien will ipso facto equally and ratably secure the payment of the Principal of, and interest and other charges on, the Loan; and (ii) that the Borrower, in creating or permitting the creation of any such lien, will make express provision to that effect.	Complied with.
		(b) The provisions of paragraph (a) of this Section shall not apply to (i) any lien created on property, at the time of purchase thereof, soley as security for payment of the purchase price of such property; or (ii) any lien arising in the ordinary course of banking transactions and securing a debt maturing not more than one year after its date.	Complied with.

COMPLIANCE WITH LOAN COVENANTS

ADB LOAN 661-PAK

Executing Agency: Pakistan Water and Power Development Authority Lahore

Covenant	Status
PARTICULAR COVENANTS	
(c) The term "assets of the Borrower" as used in Paragraph (a) of this Section includes assets of any political subdivision or any agency of the Borrower and assets of any agency of any such political subdivision, including the State Bank of Pakistan and any other institution performing the functions of a central bank for the Borrower.	Complied with.

APPENDIX 8

COMPARISON BETWEEN THE DISBURSEMENT SCHEDULE
AND
THE ACTUAL DISBURSEMENT

(Need WAPDA Input)

COMPARISON BETWEEN THE DISBURSEMENT SCHEDULE
VS. THE ACTUAL DISBURSEMENT
($ Million)

YEAR	QUARTER	LOAN = 0660-PAK(SF) PROJECTED QUARTERLY	LOAN = 0660-PAK(SF) PROJECTED CUMULATIVE	LOAN = 0660-PAK(SF) ACTUAL QUARTERLY	LOAN = 0660-PAK(SF) ACTUAL CUMULATIVE	LOAN = 0661-PAK PROJECTED QUARTERLY	LOAN = 0661-PAK PROJECTED CUMULATIVE	LOAN = 0661-PAK ACTUAL QUARTERLY	LOAN = 0661-PAK ACTUAL CUMULATIVE
1984	1								
	2								
	3								
	4					21.200	21.200	21.200	21.200
1985	1					5.740	26.940	5.739	26.939
	2	1.640	1.640			8.280	35.220	5.048	31.987
	3	1.411	3.051	1.380	1.980	3.044	38.264	5.728	37.715
	4	7.026	10.077	1.001	2.981	2.856	41.120	0.330	38.045
1986	1	0.080	10.157	0.522	3.503	2.236	43.356	1.345	39.390
	2	5.107	15.264	0.220	3.723			2.266	41.656
	3	2.100	17.364	5.535	9.258			2.470	44.125
	4	2.387	19.751	15.486	24.744			0.000	44.126
1987	1	3.765	23.516	12.005	36.749			0.088	44.214
	2	0.892	24.408	16.254	53.003			0.041	44.255
	3	3.425	27.833	5.913	58.916			0.299	44.554
	4	3.825	31.658	3.687	62.603			0.218	44.772
1988	1		31.658	1.021	63.624			0.043	44.815
	2		31.658	0.798	64.422			0.082	44.897
	3		31.658	0.273	64.695			1.049	45.946
	4	3.192	34.850	0.890	65.585			0.784	46.730
1989	1			2.933	68.518				
	2			0.000	68.518				
	3			0.000	68.518				
	4			2.933	71.451				
1990	1								
	2								
	3								
	4								

APPENDIX 9

B.S. FEEDER STUDY TEAM'S RECOMMENDATION

SUMMARY OF THE B-S FEEDER STUDY TEAM REPORT

In the last week of December 1988, a study team was constituted to look into the problem of silt build-up in the B-S Feeder Canal and in the intake structure of the 450 MW combined cycle power plant at Guddu.

A brief summary of the contents of this report is given below.

REASONS FOR SILT BUILD UP IN THE B.S. FEEDER

After extensive investigations and study of data collected by the team, it was found that extraordinary silting of the B-S Feeder had been caused by the following conditions.

1. Entry of bed silt from the right pocket of the Guddu Barrage

   As the bed silt built up in the pocket and approached the level of the canal regulator's weir crest, it carried over into the canal when the regulator gates were opened.

2. The constriction caused by the road/rail bridge at RD 17

   The bridge at RD 17 over the B-S Feeder was designed to pass 14,700 cusecs. Because the canal discharge was increased to 22,000 cusecs (a 50% increase) the bridge could not pass this quantity easily. Consequently, a damming effect occurred and silt was deposited upstream of this bridge. The silt deposit has progressively travelled backwards until the entire head reach silted up.

3. The increased width of the B-S Feeder

   The annual short term increased flow of 22,000 cusecs eroded the banks of the canal, and its bed width increased from 240 ft. to 320 ft. At lower discharges, the flow velocity therefore decreased to a point where silt could not be transported along the canal, and sedimentation therefore took place.

4. The earthen dike at RD 8

   This dike was constructed every year so that water could be ponded for WAPDA's use, which became an obstruction and caused sedimentation in the canal. Only the crest of this dike was washed away while the remainder stayed as part on the canal bed load.

5. The cross-regulator at RD 45

This regulator was also designed for a canal flow of only 14,700 cusecs. It could not easily pass the increased discharge of 22,000 cusecs and, therefore, also had a damming effect. Silt formation began upstream of this cross-regulator and progressed backwards to the bridge at RD 17.

6. Build-up of silt in the B-S Feeder

The gradual build-up of silt in the canal itself caused more sedimentation as the bed was raised and the slope of canal bed became flatter. This reduced the velocity of flow which in turn decreased the silt carrying capacity of the canal water.

Turbulence at the bridge piers, at RD 17, also brought bed silt into suspension. As the canal water could not carry this extra silt, it was deposited again at about RD 19. This hump acted as a dike causing further silting upstream.

REASONS FOR SILT BUILD-UP IN THE COMBINED CYCLE INTAKE STRUCTURE

The intake structure location was such that it invited silt build-up inside its basin. Firstly it was located on the inside of the curve in the B-S Feeder where sedimentation occurs. Secondly, the location was in the head reach of the B-S Feeder where there was heavy carry over of silt from the barrage pocket.

The intake structure also had no provision for excluding suspended silt. Nor was there any stilling basin from which the pumps could draw comparatively clear water. At high turbidity (silt concentration) levels in the canal, there was bound to be some settlement of silt in the intake structure.

RECOMMENDATIONS

The study team recommended that the following actions be taken to overcome the problems of silt-build up in the B-S Feeder and within the intake structure.

1. The B-S Feeder should be restored to its original design parameters immediately as per the recommendations of the study team's interim report on "Desilting of the B-S Feeder". The existing build-up of silt raised the canal bed to an elevation even higher than that of the weir wall of the intake structure which was designed to prevent the entry of bed load silt into the intake structure. This silt in the reach RD 0 to RD 17 was to be removed and the canal restored to its original bed profile.

2. The right pocket of the Guddu Barrage was to be flushed more often to reduce carry over of silt into the B-S Feeder. During these operations, all thermal plants at Guddu were to run off their respective cooling towers, for periods lasting up to 24 hours.

3. All cooling towers at Guddu were to be brought into good running condition, with fully functioning blowdowns.

4. The road/rail bridge over the B-S Feeder at RD 17 was to be expanded so that the restriction was removed and a discharge of 22,000 cusecs could pass without hindrance. This would keep the upstream reach free of silt.

5. A head regulator designed for a discharge of 22,000 cusecs was to be constructed at RD 18. This would obviate the need for annual construction of an earthen dike at RD 8 and would maintain a high pond elevation for supply of water to WAPDA in the winter. It would also be part of the annual scouring mechanism which would keep the canal from silting up.

6. The existing cross-regulator at RD 45 was to be widened to allow 22,000 cusecs of water to pass without hindrance. This will keep the upstream reach free of silt.

7. Regular scouring operations should be conducted by the Sind Irrigation Department when the above remedial works had been executed.

8. The canal was to be shut down for four weeks every winter so that annual canal inspection and maintenance procedures could be implemented. During this period the thermal plants would run on their cooling towers. Also, during this period localized silt deposits, if any, could be removed from the canal. WAPDA could also utilise the winter canal closure for repair and maintenance work on the intake structures.

9. The combined cycle plant's intake structure was to be equipped with gates to prevent entry of very turbid water into the intake structure during the occasional periods of high flood in the Indus River. These periods do not last for more than six weeks normally and the combined cycle plant could run in the closed-loop mode during this time.

CONCLUSION

In conclusion, it should be pointed out that the study team's recommendations constituted a complete package. Partial implementation would not solve the problems being faced by WAPDA and the Sind Irrigation Department. The study team strongly recommended total implementation of all proposals outlined in their report, beginning with immediate dredging of the canal.

APPENDIX 10

PLANT OPERATING STATISTICS

OPERATING STATISTICS

	1985 DEC	1986 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1988 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1989 JAN	FEB
STEAM TURBINE UNIT 1																																							
1 ENERGY GENERATED GWh																										42	24	22	11	54	52	56	49	62	21	42	10	58	35
2 MAXIMUM CAPACITY MW																										36	37	60	54	32	24	52	32	32	57	28	58	37	46
3 HOURS OF OPERATION Hrs																										735	574	558	195	720	552	744	721	720	322	553	720	720	650
4 FORCED OUTAGE Hrs																										6	13	12	3	25	22	8	12	8	521	22	7	5	12
5 PLANNED OUTAGE Hrs																										8	12	22	524	7	3	2	2	2	8	168	24	6	1
6 FORCED OUTAGE Nos																										8	6	6	8	8	7	2	4	8	12	2	5	2	5
7 PLANNED OUTAGE Nos																										2	1	6	1	8	8	8	8	8	8	8	8	8	8
8 RELIABILITY %																										33	37	34	27	35	37	1001	33	1008	21	73	35	35	37
9 AVAILABILITY %																										39	33	33	100	37	35	1008	38	1008	23	27	35	35	35
STEAM TURBINE UNIT 2																																							
1 ENERGY GENERATED GWh																												7	45	41	18	35	33	35	31	11	35	35	32
2 MAXIMUM CAPACITY MW																												95	96	96	32	94	94	67	48	59	31	59	32
3 HOURS OF OPERATION Hrs																												136	839	444	231	234	685	387	683	243	806	735	673
4 FORCED OUTAGE Hrs																												9	6	25	22	12	23	28	2	3	1	6	2
5 PLANNED OUTAGE Hrs																												16	75	221	646	28	8	225	32	477	225	5	8
6 FORCED OUTAGE Nos																												2	1	5	2	2	3	2	2	2	1	2	1
7 PLANNED OUTAGE Nos																												1	2	1	1	1	1	1	1	1	1	1	1
8 RELIABILITY %																												83	85	81	25	87	82	62	83	24	81	83	1008
9 AVAILABILITY %																												76	89	86	27	87	82	85	1008	1008	1008	83	1008

OPERATING STATISTICS

		1985	1986											1987											1988											1989	
		DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
GAS TURBINE UNIT 1																																							
1 ENERGY GENERATED	GWh	27	56	30	45	45	42	25	24	8	23	24	1	3	40	43	6	2	3	48	31	16	19	25	23	32	56	32	3	47	38	32	30	27	26	25	22	28	32	2
2 MAXIMUM CAPACITY	MW	123	118	115	109	106	105	104	150	108	104	104	9	9	119	114	112	9	9	105	103	102	105	30	112	118	122	117	113	102	101	100	98	112	108	126	116	124	122	2
3 HOURS OF OPERATION	Hrs	232	525	264	495	551	513	373	461	147	335	337	9	3	423	513	61	3	6	553	328	244	723	515	517	671	570	535	136	542	725	525	545	505	712	251	577	522	555	1
4 FORCED OUTAGE	Hrs	8	17	1	13	4	2	7	2	9	2	12	8	8	2	10	625	722	744	191	12	16	3	1	1	1	1	0	225	213	15	35	43	123	7	251	145	55	77	672
5 PLANNED OUTAGE	Hrs	1	22	3	147	3	3	87	76	3	21	3	723	744	240	3	3	3	3	3	43	84	3	123	223	23	55	51	223	3	3	3	3	3	3	3	3	3	3	3
6 FORCED OUTAGE	Nos	3	2	1	0	5	2	14	6	3	2	4	0	0	0	2	1	0	0	0	2	2	0	3	1	1	2	0	2	0	1	1	2	1	0	2	1	2	1	1
7 PLANNED OUTAGE	Nos	0	0	0	1	0	1	3	1	1	6	1	0	0	2	1	0	3	3	3	3	0	0	1	1	1	3	2	1	0	0	0	3	3	0	3	3	3	3	3
8 RELIABILITY	%	97	93	39	-76	99	99	80	86	98	89	95	3	3	95	97	3	0	0	75	92	59	100	83	73	95	91	91	25	72	88	84	92	89	97	91	85	90	90	3
9 AVAILABILITY	%	97	97	100	93	99	99	99	100	100	99	96	100	100	100	98	3	0	0	75	99	99	100	100	100	100	100	100	93	72	98	98	93	92	99	97	93	99	99	3
GAS TURBINE UNIT 2																																							
1 ENERGY GENERATED	GWh					49	53	52	36	10	19	31	27	68	48	48	71	67	61	46	14	0	25	37	41	54	72	55	75	46	47	57	61	53	53	42	52	54	75	73
2 MAXIMUM CAPACITY	MW					107	105	134	102	104	104	107	105	115	112	114	111	109	106	109	73	0	102	106	115	115	113	113	112	114	113	112	101	103	104	105	113	115	105	105
3 HOURS OF OPERATION	Hrs					572	664	532	458	128	263	371	471	471	558	564	637	715	729	592	212	0	438	624	553	661	719	555	742	429	511	653	549	595	714	662	555	642	744	666
4 FORCED OUTAGE	Hrs					15	0	1	13	0	17	15	9	0	0	1	10	1	1	1	0	0	0	0	1	0	0	41	156	282	222	73	94	57	0	224	228	0	3	6
5 PLANNED OUTAGE	Hrs					76	0	0	87	53	22	1	173	0	240	3	0	0	0	38	528	744	6	7	142	75	22	62	3	3	23	3	3	3	3	3	3	3	3	3	3	3
6 FORCED OUTAGE	Nos					2	0	2	1	2	2	4	4	1	2	3	4	1	1	1	0	0	1	2	1	2	1	7	2	1	2	2	1	2	1	2	2	2	2	2
7 PLANNED OUTAGE	Nos					1	1	0	2	1	4	1	0	1	1	0	0	0	0	1	1	1	1	2	1	1	1	2	2	1	2	1	2	1	2	1	2	1	2	2
8 RELIABILITY	%					86	100	100	87	71	87	91	72	100	95	100	98	100	100	95	28	3	99	98	79	99	96	87	82	93	89	95	97	95	99	93	79	100	99	99
9 AVAILABILITY	%					98	100	100	98	100	98	95	99	100	100	100	98	100	100	100	100	100	100	100	100	99	100	96	95	93	92	97	95	99	93	79	100	99	99	

OPERATING STATISTICS

		1985 DEC	1986 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GAS TURBINE UNIT 3														
1 ENERGY GENERATED	GWh				59	33	[illegible]	47	42	3	[illegible]	[illegible]	25	55
2 MAXIMUM CAPACITY	MW				112	102	[illegible]	[illegible]	109	33	104	107	106	[illegible]
3 HOURS OF OPERATION	Hrs				582	464	415	573	494	[illegible]	230	215	[illegible]	556
4 FORCED OUTAGE	Hrs				23	4	[illegible]	2	2	1	[illegible]	31	[illegible]	2
5 PLANNED OUTAGE	Hrs				4	126	0	3	35	30	[illegible]	3	3	11
6 FORCED OUTAGE	Nos				3	2	1	4	4	2	4	15	4	7
7 PLANNED OUTAGE	Nos				6	2	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	3
8 RELIABILITY	%				95	71	99	100	[illegible]	53	96	85	93	94
9 AVAILABILITY	%				95	99	99	100	100	99	100	83	95	100
GAS TURBINE UNIT 4														
1 ENERGY GENERATED	GWh							58	62	4	1	[illegible]	22	67
2 MAXIMUM CAPACITY	MW							103	102	99	102	104	102	116
3 HOURS OF OPERATION	Hrs							661	521	53	37	219	373	721
4 FORCED OUTAGE	Hrs							3	0	21	0	1	5	8
5 PLANNED OUTAGE	Hrs							9	13	15	0	3	3	3
6 FORCED OUTAGE	Nos							3	4	1	2	3	4	5
7 PLANNED OUTAGE	Nos							0	0	3	0	2	2	0
8 RELIABILITY	%							38	36	33	100	38	39	39
9 AVAILABILITY	%							100	100	87	100	100	33	39

		1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GAS TURBINE UNIT 3													
1 ENERGY GENERATED	GWh	54	12	14	56	55	55	[illegible]	51	43	[illegible]	[illegible]	[illegible]
2 MAXIMUM CAPACITY	MW	115	110	109	[illegible]	105	106	[illegible]	120	[illegible]	102	[illegible]	[illegible]
3 HOURS OF OPERATION	Hrs	[illegible]	157	142	434	565	[illegible]	[illegible]	740	[illegible]	615	[illegible]	[illegible]
4 FORCED OUTAGE	Hrs	3	8	3	8	[illegible]	1	23	1	[illegible]	[illegible]	[illegible]	[illegible]
5 PLANNED OUTAGE	Hrs	32	334	[illegible]	25	4	3	[illegible]	3	5	[illegible]	[illegible]	[illegible]
6 FORCED OUTAGE	Nos	1	3	[illegible]	2	1	2	3	1	1	[illegible]	[illegible]	[illegible]
7 PLANNED OUTAGE	Nos	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	2	[illegible]
8 RELIABILITY	%	97	[illegible]	16	96	91	100	[illegible]	100	[illegible]	[illegible]	94	[illegible]
9 AVAILABILITY	%	100	100	100	100	91	100	95	100	97	[illegible]	100	[illegible]
GAS TURBINE UNIT 4													
1 ENERGY GENERATED	GWh	58	48	58	62	63	55	43	49	[illegible]	[illegible]	52	70
2 MAXIMUM CAPACITY	MW	115	114	[illegible]	108	107	[illegible]	101	104	103	[illegible]	[illegible]	118
3 HOURS OF OPERATION	Hrs	[illegible]	519	531	684	737	[illegible]	[illegible]	712	313	[illegible]	[illegible]	742
4 FORCED OUTAGE	Hrs	153	3	3	19	0	9	[illegible]	0	408	[illegible]	3	3
5 PLANNED OUTAGE	Hrs	8	2	7	5	6	0	[illegible]	7	2	[illegible]	2	[illegible]
6 FORCED OUTAGE	Nos	2	1	3	2	2	3	2	1	[illegible]	[illegible]	[illegible]	[illegible]
7 PLANNED OUTAGE	Nos	0	1	0	1	0	3	3	0	1	3	3	0
8 RELIABILITY	%	[illegible]	39	39	37	39	100	38	39	43	[illegible]	39	100
9 AVAILABILITY	%	75	100	100	87	100	100	38	100	43	[illegible]	39	100

		1988 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1989 JAN	FEB
GAS TURBINE UNIT 3															
1 ENERGY GENERATED	GWh	[illegible]	57	[illegible]	73	[illegible]	57	[illegible]	73	[illegible]	53	[illegible]	[illegible]	[illegible]	[illegible]
2 MAXIMUM CAPACITY	MW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3 HOURS OF OPERATION	Hrs	[illegible]	[illegible]	645	[illegible]	[illegible]	[illegible]	[illegible]	744	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 FORCED OUTAGE	Hrs	4	4	4	[illegible]	[illegible]	[illegible]	113	2	[illegible]	23	[illegible]	[illegible]	[illegible]	2
5 PLANNED OUTAGE	Hrs	33	3	35	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
6 FORCED OUTAGE	Nos	2	8	8	[illegible]	2	[illegible]	1	8	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
7 PLANNED OUTAGE	Nos	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8 RELIABILITY	%	97	[illegible]	97	[illegible]	[illegible]	100	94	90	[illegible]	97	97	100	100	100
9 AVAILABILITY	%	99	100	100	[illegible]	[illegible]	100	94	100	99	97	97	100	100	100
GAS TURBINE UNIT 4															
1 ENERGY GENERATED	GWh	72	[illegible]	74	64	70	67	64	[illegible]	0	0	0	0	0	0
2 MAXIMUM CAPACITY	MW	[illegible]	[illegible]	116	109	104	[illegible]	102	102	0	0	0	0	0	0
3 HOURS OF OPERATION	Hrs	742	[illegible]	742	[illegible]	744	[illegible]	534	283	0	0	0	0	0	0
4 FORCED OUTAGE	Hrs	3	3	2	48	0	1	52	455	[illegible]	744	[illegible]	744	744	[illegible]
5 PLANNED OUTAGE	Hrs	9	[illegible]	9	[illegible]	3	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6 FORCED OUTAGE	Nos	1	3	2	3	3	2	2							
7 PLANNED OUTAGE	Nos	0	1	1	3	0	3	0							
8 RELIABILITY	%	100	[illegible]	100	[illegible]	[illegible]	100	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9 AVAILABILITY	%	100	100	100	[illegible]	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX 11

MAIN CHARACTERISTICS OF COMBINED CYCLE PLANT

MAIN CHARACTERISTICS OF 450 MW COMBINED CYCLE PLANT GUDDU

LOCATION	:	Guddu Thermal Power Station (which is approximately 160 km from Sukkur and 5 km from Kashmore, Province of Sind).
POWER STATION	:	Extension of the existing Guddu Thermal Power Station.

NUMBER OF UNITS

1. Gas Turbines & Generators four (4)

Gas Turbines	:	Simple cycle, heavy duty for outdoor installation.
Guaranteed net output at base load	:	81.7/85.64 MW (distillate fuel/Mari Gas at 50°C inlet temperature.
Generator		
Generator Voltage	:	11,500 KV
Frequency	:	50 HZ
Power factor	:	0.85 (lagging)
Generator speed	:	3000 rpm

2. Steam Turbines & Generators Two (2)

Steam Turbine

Combined Cycle unit at 50°C guaranteed out-put	:	94.720 MW
Speed	:	3000 rpm
Number of stages high pressure/low pressure	:	14/5

MAIN CHARACTERISTICS OF 450 MW COMBINED CYCLE PLANT GUDIU

Generator

Speed	:	3000 rpm
Phases	:	3
Frequency	:	50 HZ
Voltage rating	:	11,500 KV
Power Factor	:	0.85 (lagging)
Guaranteed output at 0.85 and 43°C cold gas temperature	:	100.56 MW

HEAT RECOVERY STEAM GENERATORS	:	Four (4)
Maximum steam flow at 50°C base	:	154.9 kg/HR
Steam pressure at 50°C base	:	63.3 Kg/cm^2
Steam temperature at 50°C base	:	530°C
CONDENSATE FEEDWATER PUMPS	:	Six (6)
Type	:	Vertical barrel
Capacity	:	259.1 m^3/HR
Total Head	:	954 m
Motor HP/V/HZ/Phases	:	1250 HP/6600V/50HZ/3
Speed	:	2970 RPM
MAIN CIRCULATING WATER PUMPS	:	Three (3)
Design flow	:	27,516 m^3/HR
Design Head	:	13.72 m
Maximum speed	:	330 rpm

MAIN CHARACTERISTICS OF 450 MW COMBINED CYCLE PLANT GUDDU

COOLING TOWER

Number of cells	:	8
Design water flow	:	35,020 m^3/HR
Inlet water temperature	:	47.6°C
Outlet water temperature	:	37.8°C
Heat Removed	:	344x106 K Cal/hr

COOLING TOWER PUMPS : Two (2)

Design flow	:	17,483 m^3/HR
Design head	:	21.3 m
Maximum speed	:	493 rpm

HYDROGEN GENERATION SYSTEM

Rated hydrogen production	:	12 m^3/HR
Hydrogen purity	:	99.999%

WATER TREATMENT PLANT

Demineralized water flow rate	:	416 lpm
Type	:	Anion Exchanger
	:	Cation Exchanger
	:	Mixed Bed Exchanger

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APPENDIX 12

THE EXECUTING AGENCY

THE EXECUTING AGENCY

A. History and Organization

The Water and Power Development Authority (WAPDA) came into existence in 1958 through an ordinance proclaimed by the Government of West Pakistan. Before the creation of WAPDA, major schemes for water and power development were handled by the four provincial Departments. These departments proved to be incapable of carrying out big national scheme, within schedule, thus causing delays in overall national progress.

To overcome this situation, it was felt that there was a need to create an organization:

a) Having required financial autonomy.

b) Equipped with a modern progressive machinery for execution of projects of national interest.

c) For unified development of the water and power resources of Indus plains which should not have any political barriers of provinces, divisions, etc.

The draft of the ordinance for WAPDA was drawn up on the lines of the Tennessee Valley Authority in the United States. The charter of WAPDA's responsibilities covers generation and transmission of power, irrigation, water supply and drainage, prevention of waterlogging and reclamation of waterlogged and saline lands, flood control and inland navigation.

Today, WAPDA is the biggest development organization in Pakistan. It has nearly 150,000 employees including over 7,000 engineers on its payrolls.

B. Management and Staff

WAPDA operates as a public utility under the supervision of the Ministry of Water and Power. The Ministry appoints a board of Directors which comprises a Chairman and three Members. These are Member Finance, Member Water, Member Power. These Members are assisted by Chief Engineers and Project Directors.

WAPDA's most recent organization chart is shown in appendix 13. WAPDA does not at present envisage any major changes in its organization. WAPDA will however,, consult with the Bank on the details of any major change sufficiently in advance to provide an opportunity for the Bank to Comment.

160

THE EXECUTING AGENCY

WAPDA has well-staffed and efficient planning organizations for survey, site investigation, planning of generation and transmission projects, economic studies and financial forecasting. It revises load forecasts and power development programs at least annually.

WAPDA has a training department which organizes courses and seminars for all levels of staff. The training courses organized by the department stress power plant operation and maintenance for the training of WAPDA staff in various institutions in Pakistan and abroad. WAPDA's training department has played an important role in maintaining and improving the skills of its staff.

APPENDIX 14

INSTALLED GENERATING CAPACITY,
PEAK AND ENERGY GENERATION OF WAPDA SYSTEM

WAPDA SYSTEM GENERATING CAPACITY Vs. PEAK DEMAND
NATIONAL GRID SYSTEM
(Mega Watts)

DESCRIPTION	1988						1989					
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Total Generating Capacity	5,905	6,685	6,605	6,234	6,084	6,003	5,360	5,725	5,761	5,759	5,775	6,059
Peak Demand	5,995	5,995	6,178	6,028	5,884	6,217	6,322	6,217	6,139	6,086	6,322	6,531
Surplus / Deficit	(90)	690	427	206	200	(214)	(962)	(492)	(378)	(327)	(547)	(472)
Spinning Reserve	322	400	400	378	372	362	275	325	293	267	257	263
Maintenance Reserve	474	774	774	774	774	324	0	58	236	270	87	241
Firm Generating Capacity	5,109	5,511	5,431	5,082	4,938	5,317	5,085	5,342	5,232	5,222	5,431	5,555
Net Surplus / Deficit	(886)	(484)	(747)	(946)	(946)	(900)	(1,237)	(875)	(907)	(864)	(891)	(976)

GIBBS & HILL, INC.

WAPDA - USAID - ADB GUDDU COMBINED CYCLE POWER GENERATION PROJECT

Asian Development Bank
2330 Roxas Boulevard, Pasay City
Box No. 789, Manila,
Philippines

L-3572-LADB013
June 8, 1989

Attention: Mr. Alan D. Burrell Manager Power Division (West)

Subject: Guddu 600 MW Combined Cycle Power Plant Project
Draft Project Completion Report
Responses to ADB Comments

References: 1. G&H letter L-3572-LADB012 dated April 27, 1989
2. ADB telex Q/LBC 031 dated May 15, 1989

Dear Mr. Burrell:

The attached change pages to the draft Project Completion Report issued by reference 1 are intended to be responsive to the comments provided in your reference 2 telex.

We have not been able to respond to all comments, but we believe that all outstanding items can be resolved when your PCR mission visits Pakistan.

Very Truly Yours
Gibbs & Hill Inc.

S. D. I. Reimers
Project Manager

cc: Nazim H. Siddiqui/WAPDA-Lhr w/one copy
Abdul Waris Khan/WAPDA-Lhr w/one copy
Syed Abid Ali/WAPDA-Guddu w/one copy
Lal Ghani/WAPDA-Guddu w/one copy
M. Waseem Ch./USAID-Isld w/one copy
S. M. Marano/G&H-NY w/one copy
C. F. Wiemken/G&H-NY w/o att
H. A. Siemienowski/G&H-Guddu w/ two copies
File w/o att
Project Completion Report File w/one copy

15 JUN 1989

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As the systems became available and completed, they were taken over by WAPDA. Following is a list of taking over packages accepted by WAPDA todate:

1.	Hydrogen Generation Plant	February 3, 1988
2.	Gas Chromatograph	April 15, 1988
3.	Stag Unit No. 2 HRSG's and Balance of Stag Unit No. 2	August 21, 1988
4.	Stag Unit 1 HRSG's and Balance of Stag Unit No. 1	November 19, 1988
5.	Cooling Tower	December 21, 1988
6.	Water Treatment Plant	February 15, 1989

The Lot 4 combined cycle plant systems that are still to be completed include the plant microprocessor based control system and "punch list" items.

5. Lot 5C: Central Chilling and Heating Plant

The tender document for the supply, erection and commissioning of Central Chilling and Heating Plant was issued on May 8, 1985. Bids were received on October 27, 1985. The contract was signed between WAPDA and General Electric Company of U.S.A. on February 10, 1987.

The plant was taken over by WAPDA on May 21, 1988. The guarantee period of the plant is due to be completed on May 21, 1989.

6. Lot 6A & 6B: Gas Pipeline Material Supply and Erection

The Tender documents for the supply of Natural Gas Pipeline Material (Lot 6A) including Gas Mixing Station and Dehydration Plant were issued on October 12, 1984. Bids were received and opened on December 24, 1984 and the contract was awarded to various suppliers on April 4, 1985.

Commissioning of the Mari-Guddu Gas Pipeline (Lot 6B) was completed on June 15, 1986 although Mari gas was first delivered to Guddu in February 1986.

iii. The combined cycle add-on was originally envisaged as being supplied under two turnkey contracts; Lot 4A for the HRSG's and auxiliaries and Lot 4B for the steam turbine-generators and balance of plant. At the time of preparation of the Lot 4A and Lot 4B tender documents it was decided that proposals would also be accepted for the add-on as a single contract (Lot 4). The Lot 4 proposals which were tendered were evaluated against the lowest evaluated combined Lot 4A and Lot 4B proposals. The Lot 4 proposal submitted by the General Electric Company was evaluated lowest and therefore Lot 4 replaced the separate Lots 4A and 4B.

iv. Lot 5 was originally designated as the "central control facility and data logger" and was intended to include the plant control board, a data logger, cable trays and wiring, and control room facilities such as lighting and HVAC equipment. The supply of the control panels was subsequently transferred to the main turnkey packages and Lot 5 was divided into three sub-lots. The data logger was designated Lot 5A. It was intended that the data logger computer system supplement the conventional plant control system by performing logging and alarming functions, storage of historical data, sequence of events recording and plant performance calculations. A plant simulator, to be used for operator training purposes, was proposed as an additional item (it had not been identified as a project component at the appraisal stage) and designated Lot 5B. The central control facility heating and chilling plant was designated Lot 5C. Lot 5A was subsequently abandoned as a separate contract since the Lot 4 contractor offered a computerised plant control system with integrated data logging capability. It was also decided not to proceed with the Lot 5B simulator since a combined cycle plant simulator was being purchased by WAPDA, under West German financing, for the WAPDA training center in Faisalabad. The original Lot 5 was therefore reduced to Lot 5C, the heating and chilling plant.

v. A number of components and items of equipment were procured from foreign sources outside the supply of the main turnkey packages. These procurements were necessitated by unforeseen project developments and were financed by both the ADB and USAID. To give one example, it became evident in mid-1985 that the main gas pipeline and gas mixing station would not be available to support the initial start-up of the first two gas turbines. A

The loan closing date originally set for August 31, 1987 has already been extended to August 31, 1989. WAPDA is in the process of requesting the Bank for another extension to August 31, 1991.

As of February 28, 1989, an amount of $47.31 million has been disbursed from loan No. 0660-PAK leaving a balance of $10.19 million. Also an amount of $71.29 million has been disbursed from loan No. 0660-PAK(SF) leaving a balance of $28.52 million.

It should be noted that loan 0660-PAK(SF) was for SDR 78,733,000, which at the time of loan signature was equivalent to $83.4 million. Due to the change in the parities of various international currencies, the equivalent of SDR 78,733,000 is now $99.81 million, which partially accounts for the difference in the increased balance for Loan No. 0660-PAK(SF). Another reason was the non utilization of approximately $10 million reserved for the unallocated loans. Appendix 3 shows the disbursement schedule compared with actual disbursement.

Initial Operation

The project has been operating successfully since commissioning. Some problems were encountered as summarized below:

i. Lots 1A and 1B: Gas Turbine-Generators

Significant problems encountered during commissioning and initial operation included the following:

The "SSS" clutch systems, which are required for synchronous condenser operation, were scaled up versions of a similar, earlier design by the same manufacturer. This introduced unanticipated problems which resulted in the failure of pawl and ratchet assemblies. Parts of modified design appear to have resolved this problem.

Gas turbines hot gas path component problems, primarily associated with the combustion liners, their seals and the transition pieces, have been resolved by the manufacturer, GE.

The synchronous condenser pony motors and torque convertors were undesigned and were replaced with larger units.

The 6.6 KV auto bus transfer scheme was also modified by GE.

All of the above modifications were carried out at no cost to WAPDA.

Closure of a 220 KV breaker resulted in severe damage to the gas turbine No. 4 step-up transformer. The closure is believed to be the result of operator error. Steps taken to preclude a recurrence include the removal of the middle breaker control switches in the switchyard local control panel and operating procedure changes to require that the generator isolator switch is opened as soon as the generator breaker is tripped. It is also planned to centralize all 220 KV switchyard breaker controls in the combined cycle plant central control room.

ii. Lot 4: HRSG's, Steam T-G's and BOP

GE started construction at the site in June 1986. By the end of 1986, it became apparant that the schedule had already slipped. Estimated site progress at the end of the year was 15 percent against the approximately 40 percent required to meet the schedule. Much of this delay was attributed to the non-availability of equipment and material at the site. Although the pace of material deliveries increased during 1987, and by March over 40 percent completion had been achieved, progress remained below the required level.

Workaround schemes were developed whereby only essential systems would be completed, so that the units could be synchronized at the earliest possible date with the remaining works to be completed after the plant started generating power. As a result, even though the machines started generating power in December 1987 and March 1988, much work remained to be done throughout 1988. As of April 1989 outstanding work is mostly confined to "punch list" items and the DATATRONICS Control System.

During commissioning of the plant, problems were encountered with condensate/feedwater pumps, HRSG tube sheet distortion and bypass damper leakage. This latter also affected the output of the plant. The damper leakage problem and the HRSG tube sheet distortion problems were corrected. The condensate/feedwater pump problem is significant in that the pumps do not have sufficient NPSH. There is no obvious feasible solution, although several possibilities have been discussed. A team of GE engineers and their consultants will be visiting Guddu in June 1989 with the objective of defining a design solution. Their recommendations will be closely reviewed by WAPDA and G&H.

Problems resulting from silting of the B-S Feeder Canal are discussed in paragraph iii.e below.

iii. Measures taken to ensure continued smooth operation of the project.

In order to ensure the continued smooth operation of the Combined Cycle Plant the following measures were taken:

a) Gas turbine hot gas path: During the initial operation of the gas turbines, problems were noticed in the hot gas path components. These problems were overcome by General Electric's implementation of a part modification and replacement program. A GE Resident Engineer remained on site during the entire period to rectify the problems and keep the machines running.

b) Fuel Gas Supply:

Although the reference fuel for the gas turbines is Mari gas, Sui gas was used extensively during the initial operation period (see paragraph B.1.v). This gas was found to be high in liquid hydrocarbons. The filters installed at Guddu for this gas were also found to be inadequate. Gas problems compounded the gas turbine hot gas path component problems discussed above. A fuel gas supply study team consisting of WAPDA, General Electric and Gibbs & Hill representatives and an independent consultant was formed to evaluate the gas fuel situation. The team's charter was to recommend the remedial measures to be taken. The team established that the liquid hydrocarbon problem was associated primarily with Sui gas. They recommended that Sui gas should not be used in the gas turbines until new filters and other equipment are installed at Guddu. The team members further recommended the addition of new filters and a scrubber at the Mari field and the addition of gas heaters and a scrubber after the mixing station at Guddu. The purpose of the heater is to vaporize the liquid hydrocarbon mist in the gas. The gas heater has already been installed. The additional gas filters and scrubbers are on order and completion of installation is scheduled for July 1989.

c) Training of Personnel

In order to familiarize WAPDA personnel with the plant systems and equipment, both hands-on and class room training were provided at site. Senior WAPDA engineers who attended this training are presently imparting the knowledge gained to their junior staff.

111

d) Supply of Spares

Spare parts are essential for smooth and continuous operation of the plant and the supply of spares was given top priority. WAPDA originally purchased only the essential spare parts, sufficient for first year's plant operation. However, additional orders were recently placed for 3-5 year and 10 year supply of spares.

e) Intake Structure:

Intake structure problems became apparent during last summer's floods which caused considerable damage to the intake structure equipment. A study team was formed with members from WAPDA, USAID, G&H and GE to investigate the sources of problems and recommend solutions.

The team's most significant conclusions were as follows:

1) The B-S Feeder canal should be restored to its original design bed level which presently is over 3 meters above the original bed level.

2) The road/rail bridge over the B-S Feeder canal, downstream of the plant should be expanded so that its flow constriction is removed and full discharge is passed without hindrance. This would reduce the build up of silt in the canal at the power station.

III. EVALUATION OF IMPLEMENTATION

A. Project Components

31. WAPDA's energy production in the past decade has been less than the maximum demand. The annual growth in energy sales has averaged 9 percent while the growth in maximum demand has been 12 percent. Augumentation of generating capacity through the addition of thermal plants, which take a shorter time to construct and bring into operation than hydroelectric units, was seen as part of the solution of this problem. Availability of thermal plants, which are not effected by water availability, is also greater than that for hydro units. Also the lead time required to bring gas turbine units into operation is relatively short.

32. The original decision to develop a thermal power station at Guddu was made in 1966. The selection of Guddu as a power plant site was based on the availability of natural gas from the nearby Sui gas fields, an abundant supply of cooling water from the Indus River upstream of the Guddu Barrage, and, most importantly, the fact that Guddu is well situated geographically for supplying electrical energy to Upper Sind, Baluchistan and the Southern Punjab. These reasons still held good when the decision was made to install the 450/600 MW Combined Cycle facility. The Guddu Power Station is at a key location on the 132 KV, 220 KV and 500 KV transmission systems and was an obvious site for additional generating capacity. The gas fuel supply to Guddu is sufficient to support the 300 MW combined cycle plant expansion project for which evaluation of tenders has recently started. The availability of trained staff, site facilities and an established housing colony favors further expansion. However any extension beyond the planned 300 MW expansion project would be dependent upon additional gas supplies and/or a decision to operate one or more of the conventional steam plant units on oil.

Combined cycle power plants operate at considerably greater efficiency than conventional reheat steam boiler/turbine units and cost substantially less on an installed kilowatt basis. Their modular construction provides greater generating flexibility as do other inherent characteristics of this type of plant (e.g. the load change rate capability is about four times that of a conventional plant). WAPDA has had many years of experience with gas turbines and this technology features significantly in WAPDA's thermal plant expansion program (e.g. the eight gas turbines at the Kot Addu Thermal Power Station). Although the Guddu 450/600 MW plant is WAPDA's first combined cycle plant it does not present WAPDA with technological innovations that are new to them, except for the distributed microprocesser plant control system (which, of course, is not a control system which is unique to combined cycle plants).

33. In the combined cycle mode the plant provides a thermal efficiency of around 45 percent. This compares with 30 percent for simple cycle gas turbines and 36 percent for conventional boiler/steam turbine plant. A comparison of guaranteed versus actual gas turbine performance test results is as follows (data are corrected to 50 °C ambient conditions):

	Guaranteed	Generated Adjusted for Actual Gas Used	Actual (Average of 4 Units)
Output MW	84,685	85,640	87,428
Heat Rate kJ/kW.hr	12,003	11,950	11,544
Fuel Consumption SCFH	-	-	1,474,420

A comparison of guaranteed versus the combined cycle add-on preliminary performance test results is as follows (data are corrected to 30 °C ambient conditions):

114

	Guaranteed	Unit No. 1	Unit No. 2
Output MW	96,680	98,268	99,588

B. Project Cost

34. The actual cost of the project was $254.7 million, which is 29.7 percent below the estimated cost of $362.2 million. A detailed comparison of the appraisal estimates and actual and estimated costs is given in Appendix 5.

35. The substantial cost underrun which was achieved is attributed to the lower than anticipated prices for the combined cycle add-on, switchyard extension and gas pipeline materials and equipment contracts. It should be noted that both the power plant and oil and gas equipment industries were in a depressed state during the periods over which the equipment was purchased. This resulted in extremely competitive bidding situations.

C. Project Schedule

36. The gas turbine-generators were commissioned four (4) months late compared to the project appraisal schedule. The delay in completion is attributed to the fact that gas turbine plant Lot 1A and 1B contracts were awarded five (5) months later than the appraisal schedule. Tenders were submitted in October 1983 as originally planned. The three month schedule for bid evaluation and contract negotiations indicated on the appraisal schedule was not realistic however. Almost eight months were required for evaluation and award. This is not considered excessive for a project of this nature. Both gas turbine-generator installations were completed within shorter time spans than provided for in the appraisal schedule. This reduced the delay from five to four months.

37. The steam turbine-generators were commissioned 19 months later than envisioned in the appraisal schedule. The reasons for this delay were as follows:

38. The contract for the Lot 4 Combined Cycle add-on of HRSG's, steam turbines, balance of plant and auxiliaries was awarded in mid-March 1986, over 19 months behind the appraisal schedule. There were several reasons for this delay. The original pre-award schedule was too ambitious allowing only four months for preparation of the tender documents (with document preparation being started in October 1983, which was before the engineer started his work), three and one-half months for the bidding process and two months for the evaluation of proposals. In actual fact the bidding

116

documents were issued on August 1, 1984 which was five months behind the appraisal schedule. The bidding and evaluation process turned out to be complex and time consuming for a number of reasons, including the following:

- two envelope (technical and pricing) bidding: (single envelope bidding would have permitted short listing and thus reduced the evaluation schedule)

- the Lot 4 and the Lot 4A plus Lot 4B breakdowns for proposals: (the bidding process confirmed that a Lot 4 plus 4B breakdown was not necessary to ensure competitive bidding)

- the large number of bidders and proposals

- difficulties in determining the substantive responsiveness of certain bidders: (particularly in the area of satisfying experience criteria; one bidder in particular was evasive in providing experience data)

- objections to the bidding and evaluation process raised by certain bidders: (which had to be responded to, despite the fact that such objections were without basis)

- extensive and time consuming clarification meetings with each responsive bidder: (necessary, because of the two envelope bidding system used)

39. The Lot 4 contract was finally awarded in mid-March 1986 which was 19 months later than appraisal schedule. At the time of award it appeared that part of the delay already incurred would be recovered, since the Lot 4 contractor, the General Electric Company, had proposed a 21 month schedule from award to Taking Over as compared with the 29 months envisaged in the appraisal implementation plan.

117

The Lot 4 Units 1 and 2 began to generate electricity in December 1987 and March 1988 respectively which was approximately 14 months behind the appraisal schedule. Taking Over of Unit 1 was finally accomplished in November 1988 and of Unit 2 in August 1988. This represented a 22 months slippage with respect to the appraisal schedule. Part of the schedule slippage is attributable to the late delivery of equipment and material to the plant site. There were also many events which contributed to the delays but were beyond the contractor's control.

GUDDU 450/600 MW COMBINED CYCLE POWER PLANT

BREAKDOWN OF TURNKEY PACKAGES (LOTS)

Lot No.	Description	Financing Agency Foreign Currency	Financing Agency Local Currency	Contractor
6A	Package III, V and VI for supply of valves and supply and erection of gas mixing station and dehydrator	ADB	GOP (WAPDA)	Siirtec S.p.A. (Italy)
6A	Package IV for supply of pipe coating materials	ADB	n/a	Caroplast Fritz Muller (West Germany)
6A	Package VII for supply of Cathodic protection materials	ADB	n/a	Phoceenne de Metallurgie (France)
6A-1	Standby Sui gas reducing	n/a	GOP (WAPDA)	Petrocon Ltd (Pakistan)
6B	Gas pipeline installation	ADB	GOP (WAPDA)	Petrocon Ltd (Pakistan)
-	Fuel gas heaters	n/a	GOP (WAPDA)	Mono Impex (Pvt) Ltd (Pakistan)
-	Steam & condensate piping for chiller plant	n/a	GOP (WAPDA)	Industrial Engineering Services (Pakistan)
-	Steam & condensate piping for fuel gas heaters	n/a	GOP (WAPDA)	Fair Field (Pakistan)
-	HSD oil decanting system and tank interconnection piping	n/a	GOP (WAPDA)	Erection Engineers & Contractors (Pakistan)
-	Miscellaneous mechanical piping systems	n/a	GOP (WAPDA)	Fair Field (Pakistan)
-	Temporary fire protection system	n/a	GOP (WAPDA)	Erection Engineers & Contractors (Pakistan)
-	Supply and installation of cooling water piping to the gas turbine heat exchangers	n/a	GOP (WAPDA)	Petrocon Ltd (Pakistan)
-	Cooling water supply and return piping for chiller plant	n/a	GOP (WAPDA)	Al-Hamra Trading Co. (Pakistan)
-	Installation and tie-in of PECO filters	n/a	GOP (WAPDA)	Procon Ltd (Pakistan)

MAIN CHARACTERISTICS OF 450 MW COMBINED CYCLE PLANT GUDDU

LOCATION	:	Gudd. Thermal Power Station (which is approximately 160 km from Sukkur and 5 km from Kashmore Province of Sind).
POWER STATION	:	Extension of the existing Guddu Thermal Power Station.

NUMBER OF UNITS

1. Gas Turbines & Generators four (4)

Gas Turbines	:	Single cycle, heavy duty for outdoor installation.
Guaranteed net output at base load	:	87.7/85.64 MW (distillate fuel/Mari Gas a 50°C inlet temperature.
Generator		
Generator Voltage	:	11.5 KV
Frequency	:	50 HZ
Power factor	:	0.85 (lagging)
Generator speed	:	3000 rpm

2. Steam Turbines & Generators Two (2)

Steam Turbine

Combined Cycle unit at 50°C guaranteed out-put	:	94.720 MW
Speed	:	3000 rpm
Number of stages high pressure/low pressure	:	14/5

MAIN CHARACTERISTICS OF 450 MW COMBINED CYCLE PLANT GUDDU

Generator

Speed	:	3000 rpm
Phases	:	3
Frequency	:	50 HZ
Voltage rating	:	11.5 KV
Power Factor	:	0.85 (lagging)
Guaranteed output at 0.85 and 43°C cold gas temperature	:	100.56 MW

HEAT RECOVERY STEAM GENERATORS	:	Four (4)
Maximum steam flow at 50°C base	:	154.9 MT/HR
Steam pressure at 50°C base	:	63.3 Kg/cm^2
Steam temperature at 50°C base	:	530°C
CONDENSATE FEEDWATER PUMPS	:	Six (6)
Type	:	Vertical barrel
Capacity	:	259.1 m^3/HR
Total Head	:	954 m
Motor HP/V/HZ/Phases	:	1250 HP/6600V/50HZ/3
Speed	:	2970 RPM
MAIN CIRCULATING WATER PUMPS	:	Three (3)
Design flow	:	27,516 m^3/HR
Design Head	:	13.72 m
Maximum speed	:	330 rpm

MAIN CHARACTERISTICS OF 450 MW COMBINED CYCLE PLANT GUDDU

COOLING TOWER

Number of cells		8
Design water flow		35,020 m^3/HR
Inlet water temperature		47.6°C
Outlet water temperature	:	37.8°C
Heat Removed	:	344 x 10^6 K Cal/hr

COOLING TOWER PUMPS : Two (2)

Design flow	:	17,483 m^3/HR
Design head	:	21.3 m
Maximum speed	:	493 rpm

HYDROGEN GENERATION SYSTEM

Rated hydrogen production	:	12 m^3/HR
Hydrogen purity	:	99.999%

WATER TREATMENT PLANT

Demineralized water flow rate	:	416 lpm
Type		Anion Exchanger
		Cation Exchanger
		Mixed Bed Exchanger