No. 35

THE ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT
OF
FEASIBILITY STUDY
ON
WEST WHARF THERMAL POWER PLANT PROJECT

MAY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Japanese Government decided to conduct a survey on the Feasibility Study on West Wharf Thermal Power Plant Project in Karachi and entrusted the survey to the Japan International Cooperation Agency.

The J.I.C.A sent to Pakistan a survey team headed by Mr. Katsumi Takasawa of Tokyo Electric Power Services Co., Ltd., three times in the period from November 1987 to March 1988.

The team exchanged views with the officials concerned of the Government of Pakistan and conducted a field survey at West Wharf Thermal Power Station, and power transmission networks of KESC. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the Development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

May, 1988

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

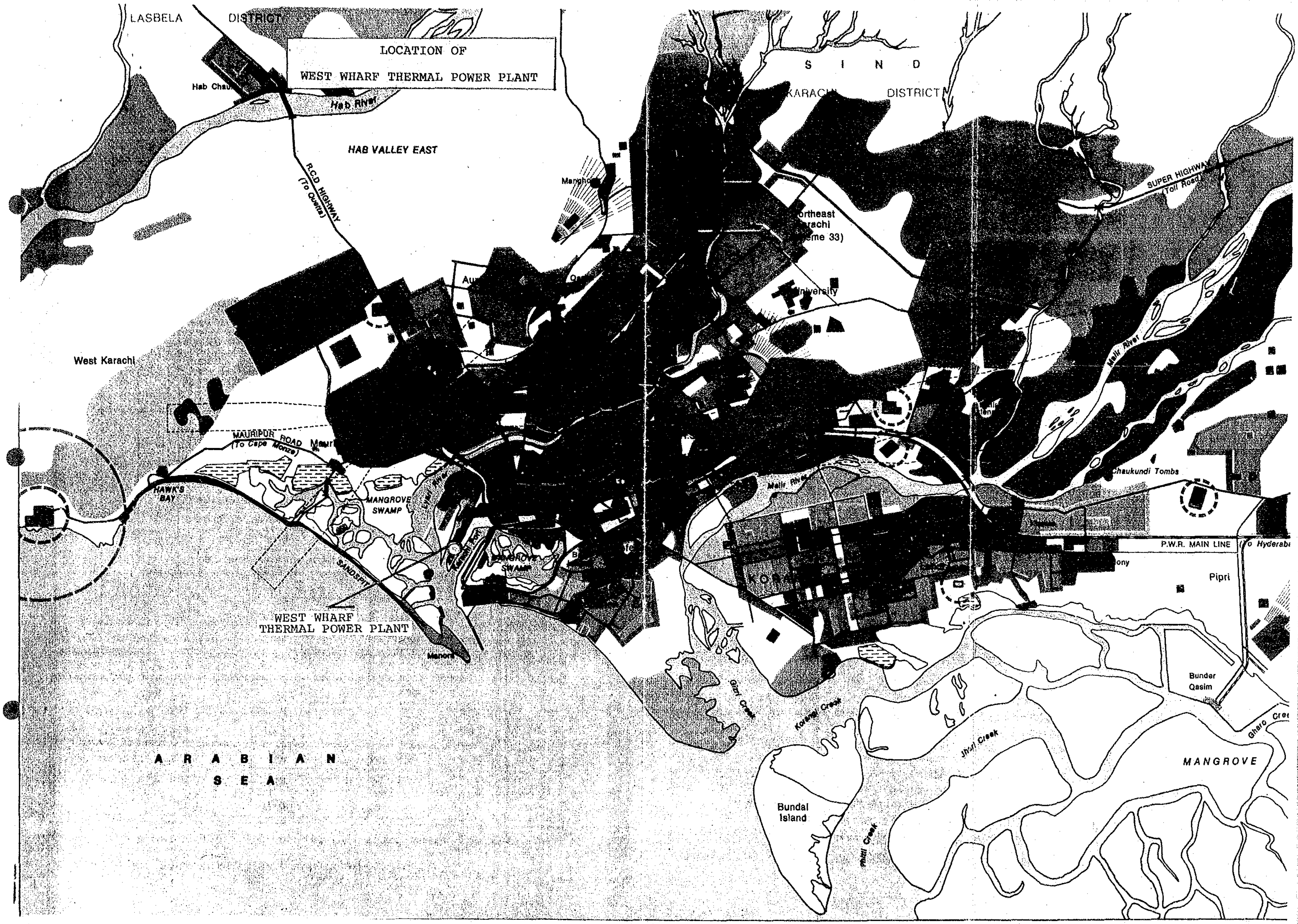
REFERENCE MAPS AND PHOTOGRAPHS:

1. LOCATION OF THE WEST WHARF THERMAL POWER PLANT

2. PHOTOGRAPHS OF THE EXISTING WEST WHARF THERMAL POWER PLANT

3. LOCATIONS OF "A", "B" AND "BX" STATIONS IN THE WEST WHARF POWER PLANT

4. ABBREVIATION LIST OF MAJOR PROPER NOUNS



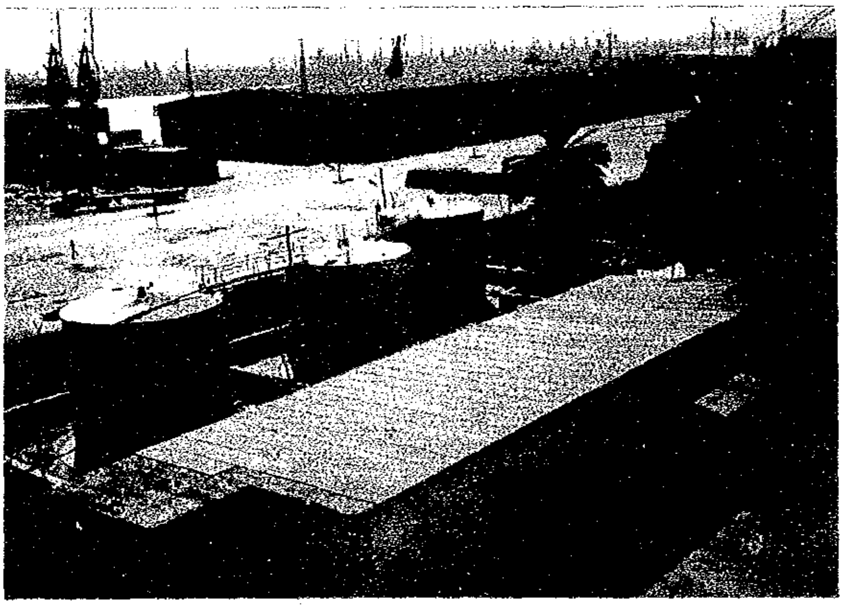
LOCATION OF
WEST WHARF THERMAL POWER PLANT
LASBELA
DISTRICT
Hab River
HAB VALLEY EAST
R.C.D HIGHWAY
(To Quetta)
S I N D
DISTRICT
SUPER HIGHWAY
(Toll Road)
University
West Karachi
MAURIPUR ROAD
(To Cape Monze)
HAWK'S BAY
MANGROVE SWAMP
SANDSPIT
Malir River
Chaukundi Tombs
P.W.R. MAIN LINE
Pipri
WEST WHARF
THERMAL POWER PLANT
Manora
Gizri Creek
Korangi Creek
Bunder Qasim
Jhari Creek
MANGROVE
Bundal Island
Phitti Creek
A R A B I A N
S E A

カラチ港湾局側（KPT）からのウエストワーフ発電所外観

(View from Karachi Port Trust Side)

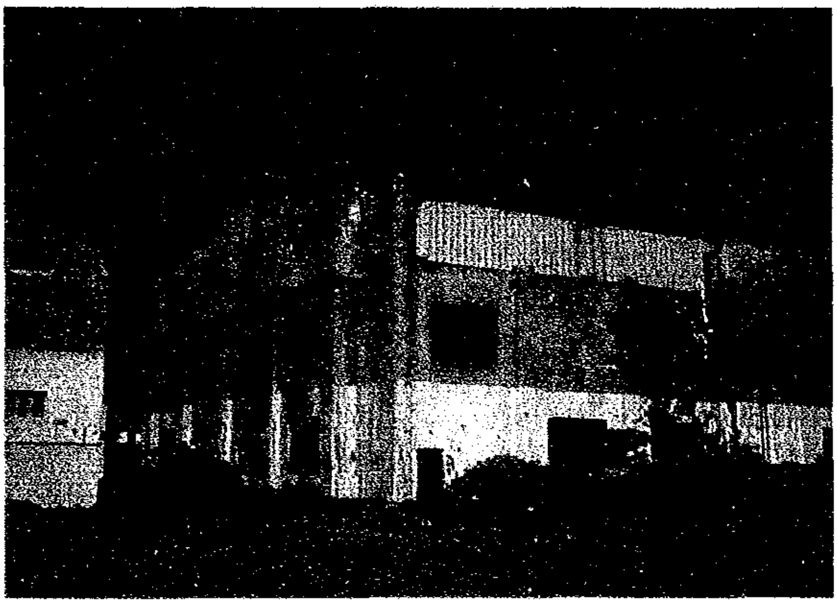
カラチ港湾局側（取水路側）

(View of Karachi Port Trust Area)

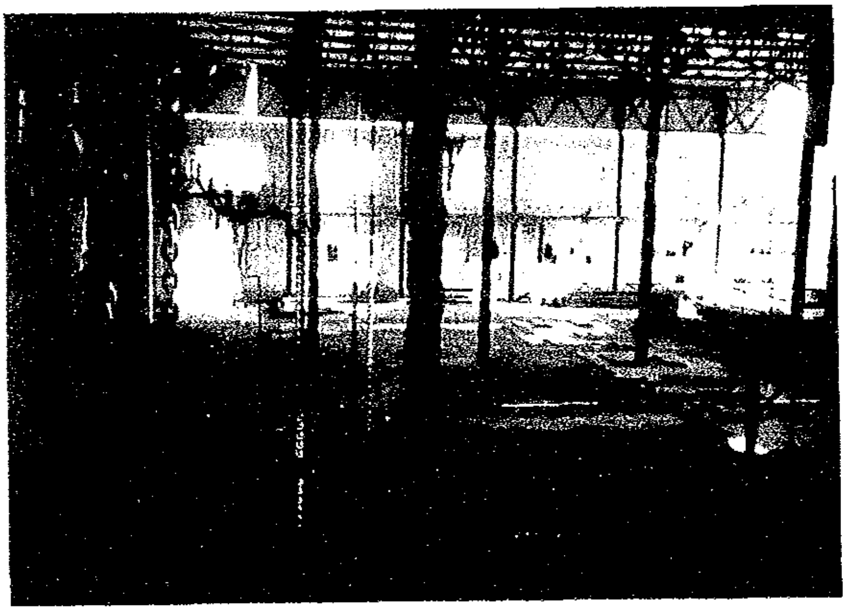


"A" 発電設備外観及び内観

(Outside View of "A" Station)

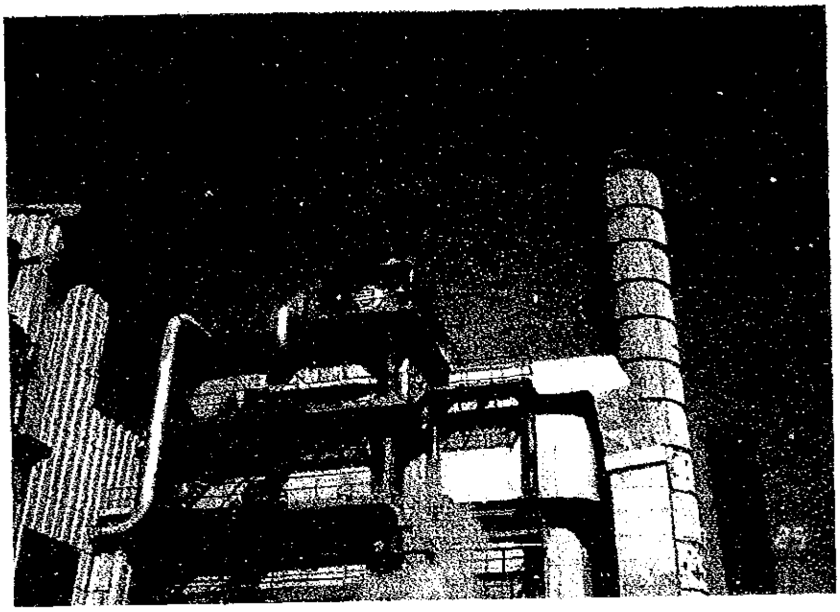


(Inside View of "A" Station)



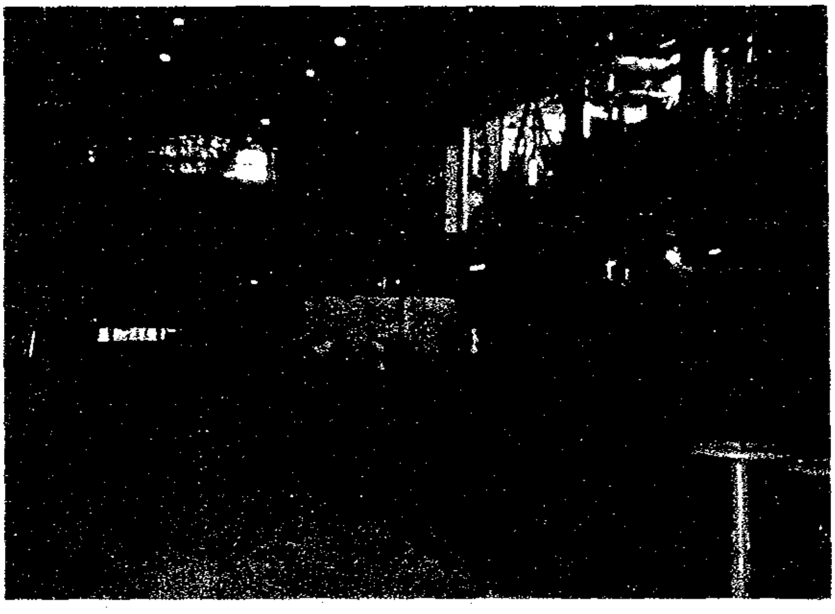
"B" "BX" 発電設備外観

(Outside View of "B" and "BX" Stations)



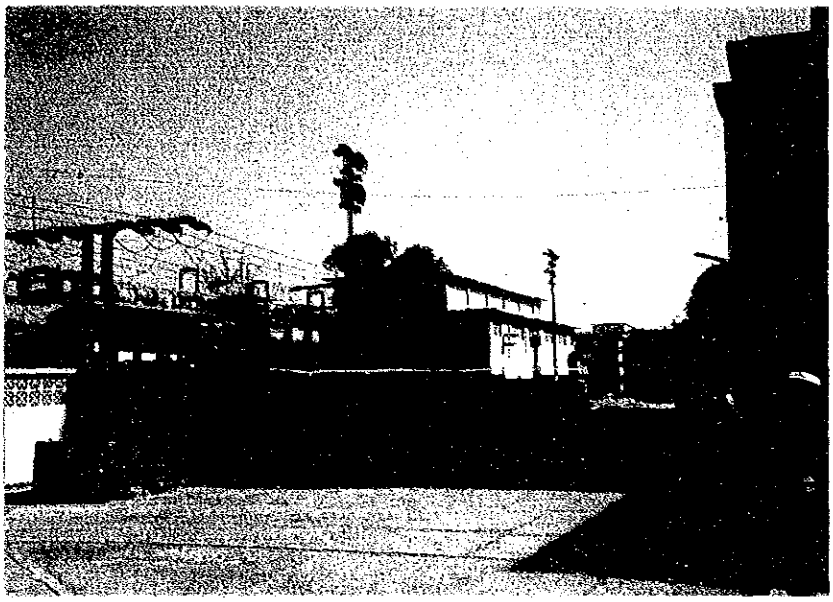
"BX" 発電設備内観

(View of "BX" Turbo Generating Facilities)



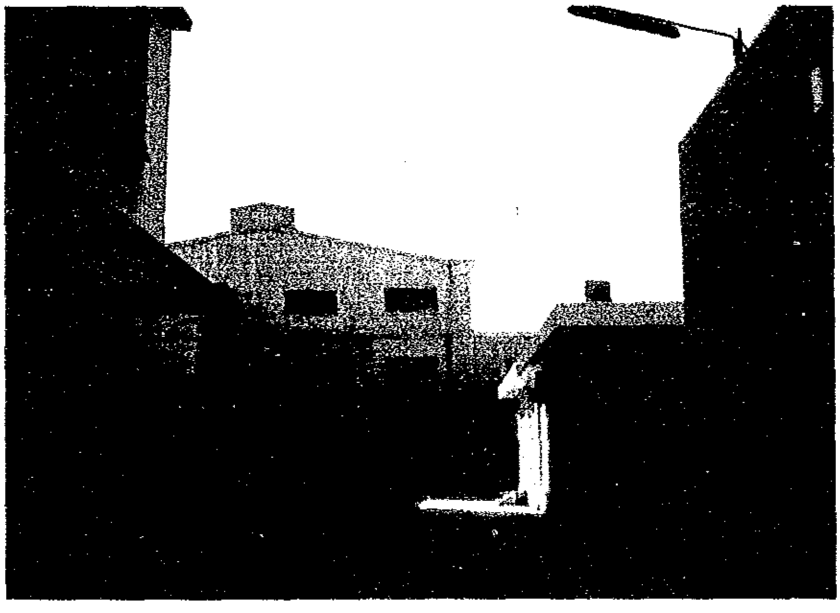
電気設備外観

(View of Electrical Facilities)



" B" " BX" 発電設備側からみた" A" 発電設備建屋外観

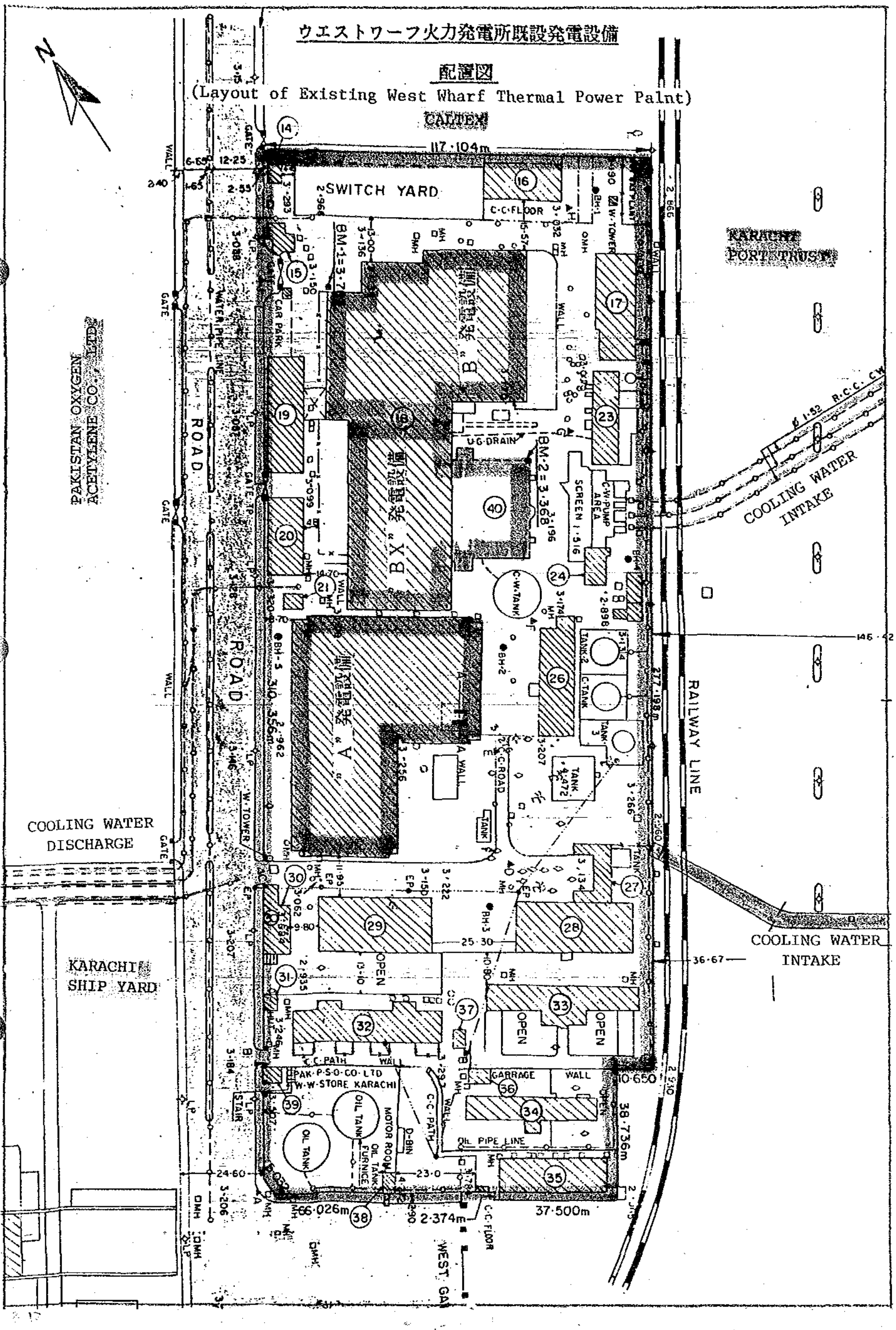
(View of "A" Station Area)



ウエストワーフ火力発電所既設発電設備

配置図

(Layout of Existing West Wharf Thermal Power Palnt)



Abbreviation List of Major Proper Nouns

In this report, the following abbreviations are used for major proper nouns.

	Abbreviation
1. Organizations and Companies	
Karachi Electric Supply Corporation Ltd.	KESC
Water and Power Development Authority	WAPDA
Pakistan Atomic Energy Commission	PAEC
Karachi Port Trust	KPT
Karachi Shipyard Engineering and Works	KSY
Caltex Oil Ltd.	CALTEX
Pakistan Steel Mill Corporation	PASMIC
2. Power Plants and Electric Power Facilities	
West Wharf Thermal Power Plant	W.W.P.P.
ditto, Unit No. 1 and No. 2	W.W.1 and W.W.2
Bin Qassim Thermal Power Plant	B.Q.P.P.
ditto, Unit No. 1, No. 2, so on	B.Q.1, B.Q.2, -----
Karachi Nuclear Power Plant	KANUPP
Baldia Grid Station, etc.	Baldia G/S, etc.

TABLE OF CONTENTS

Chapter 1. SUMMARY

1.1 Background of the Project

1.1.1

At the West Wharf Power Plant located along the coast of Karachi Bay and owned by Karachi Electric Supply Corporation Ltd., (hereinafter referred to as "KESC"), there are four existing units; namely, two (2) 15 MW units and two (2) 33 MW units which had been constructed in 1956 and 1962, respectively.

As a result of their reduction in power generation efficiency together with aging of the power unit equipment, the operation and maintenance costs of this power plant have risen year after year.

Furthermore, as the electric power demand of KESC is growing steadily, KESC is planning to decommission the existing power units in order to construct larger and more efficient power generating facilities.

The existing plant is located near the load center of Karachi and is advantageous in fuel supply due to its location adjacent to the oil terminal of CALTEX as well as its convenience in view of the availability of the existing infrastructures, KESC is planning to construct one (1) or two (2) 200 MW class power plants.

For immediate implementation of this power plant construction project, the Government of the Islamic Republic of Pakistan had requested the Government of Japan to execute a project feasibility study, including detailed design, in April 1987.

In response to the request for technical cooperation pertaining to the study on the above-mentioned thermal power plant development project, a preliminary study team comprised of five members of the Japan International Cooperation Agency (JICA) was dispatched by the Government of Japan from August 10 through August 22, 1987 for the purpose of study on the contents of this project and for discussions with the relevant authorities of Pakistan prior to full scale study.

In accordance with the results of discussions with the study team and relevant authorities of Pakistan, the scope of work (S/W) was exchanged between both parties. Following to the preliminary study, the Feasibility Study was begun on Nov. 23rd, 1987 and completed by the end of May 1988.

1.1.2 Outline of Study Area and Project

Karachi City, in which the West Wharf Thermal Power Plant (W.W.P.P.) is located, is the largest city in Pakistan and an important commercial and industrial center.

The West Wharf Thermal Power Plant was constructed on the West Wharf area of Karachi Bay and lies within the total site area of about 37,000 m2.

This site area is located near the load center of Karachi, and its north side is adjacent to the oil terminal of CALTEX. The west side faces the West Wharf Road and comprises land owned by the Pakistan Navy on the south side of this road. Further down on the west side of this road are the Pakistan Oxygen & Acetylene Co., Ltd. and the Karachi Shipyard. The east side border of this site faces the wharf belonging to Karachi Port Trust (KPT), and has a width of approximately 150 m.

The power plant is comprised of Stations "A", "B" and "BX".

However, Station "A" had been decommissioned and almost all equipment and machinery were dismantled. Only some vacant buildings remain.

Station "B", having two generating units with a total output of 30 MW (15 MW x 2), was commissioned in 1956; Station "BX" has two (2) 33 MW units which had been constructed in 1962.

As a result of reduction in the output and efficiency of plant equipment due to aging, the operation and maintenance costs of Stations "B" and "BX" have become increasingly high. Due to the above situation, operation of Station "B" was discontinued. Station "BX", which still serves as an important power supply source for the Karachi City center and the West Wharf area, has also aged considerably. As a result, KESC intends to dismantle both stations, and then construct new power plants.

1.1.3 Electric Facilities of KESC

The Water and Power Development Authority (WAPDA) is a large government organization established mainly for the purpose of power generation and irrigation services and supplies about 80% of the nation's total electric power needs.

KESC, a public enterprise with the majority of shares held by the Pakistan Government, also supplies electric power, namely, about 20% of the total power demand to Karachi and the surrounding area. These two large power systems, WAPDA and KESC, are interconnected through 220 kV and 132 kV transmission lines, enabling exchange of power between them. However, due to the tight electric power supply situation, WAPDA has not been able to supply KESC with any extra power.

As of June 1987, KESC had a total installed generating capacity of 1,108 MW, comprising some 883 MW of gas/oil fired steam plants and 225 MW of gas turbine plants furnishing power to about 830,000 consumers in its licensed area.

The maximum system demand and total energy sales in the KESC licensed area (excluding sales to WAPDA) in 1986 were 945 MW and 3,963 GWh, respectively.

At present, the major power plants of KESC consist of the Bin Qasim Power Plant (B.Q.P.P. 420 MW), the Korangi Thermal Power Plant (382 MW), the Korangi Gas Turbine Power Plant (100 MW), the S.I.T.E. Gas Turbine Power Plant (125 MW) and other smaller facilities, excluding the West Wharf Power Plant.

1.2 Basic Concept of the Development Plan

1.2.1 Procedures of the Feasibility Study

(1) This study was carried out at the request of the Government of the Islamic Republic of Pakistan. Assessed was the technical and economic feasibility of decommissioning the aged West Wharf Thermal Power Plant, which has been in continuous operation, and building a large-scale thermal power plant in its place. The aim of this project is to meet the steadily growing power demand of KESC, which supplies electric power to Karachi City and its environs.

In carrying out this Feasibility Study, the JICA study team conducted a field survey of the existing West Wharf Thermal Power Plant and related power transmission and substation facilities, keeping in mind the KESC general operation and management situation.

The study was carried out as summarized below.

The first step was to study the need for early development of new power sources. In doing this, the present electric power supply situation and the KESC forecast of demand were studied.

The second step was a technical and economic study to determine the capacity and specifications of the thermal power plant equipment that would best suit the redevelopment plan of the West Wharf Thermal Power Plant proposed by KESC as a new power source. Various restricting conditions, including availability of site, acquisition of cooling water and fuel, environmental impact, etc., were also studied.

The third step was a study of the need for power transmission and substation facilities associated with the new thermal power plant, while upgrading the reliability of the total power system of KESC.

Finally, an economic study was conducted of various factors, including alternative plans for the type and capacity of thermal power plant equipment. This study included estimates of construction and power generation costs and an examination of the advisability of the project from a long term economic point of view.

1.2.2 Basic Plan of the Project

(1) In accordance with the above-mentioned procedures, the study team carried out an investigation of electric power demand in Karachi City and the surrounding area, examined future power demands and studied the present and future power demand structure. Data, based on forecasts of demand prepared by KESC and information obtained by a site survey conducted by the study team, were analyzed. (Refer to Fig. 1-1)

The methods available for electric power demand forecasts generally consists of determination of a cumulative category-wise consumer demand and a statistical method based on elastic values of electric power demand using macro-economic indices and a trend analysis of past electric power demand.

The study team conducted trend analysis of the past records of power demand considering demand forecasts obtained from KESC. Though on a yearly basis, no constant growth rate was recorded over the past few years, a 9% or higher annual average growth rate was determined to be expected on a mid-term basis.

The annual demand for power substantially increased at the same time when new power sources, such as the Bin Qasim Power Plant Units 1 and 2, were developed. In other words, as a result of advance investment in equipment, supply and demand will show a tendency to balance out when new power facilities are completed.

When the above trends are studied in terms of power supply and demand, we can see that the daily load curves indicate the peak demands were about 945 MW in the summer and 884 MW in the winter of 1987, when the available output of KESC was 1,039 MW.

This indicates the necessity of operating almost all existing power plants at near 100 percent capacity, with almost no surplus output even at the time of periodic inspections of an existing large scale (200 MW class) thermal power plants. Thus, the problem remains to secure adequate reserve power in the KESC power systems.

This trend is predicted for the future as well. In 1991, when Bin Qasim Power Plant Unit No. 5 (210 MW) is scheduled to be commissioned, subsequent to completion of Bin Qasim Units Nos. 3 and 4 (210 MW x 2 units), the available output of KESC will reach 1,658 MW. When the annual peak demand, which is forecast to reach 1,558 MW is taken into account, we can see that power supply shortages will be unavoidable when the largest capacity unit (210 MW class) in the power system is shut down. Should this happen, it would be necessary to restrict power plant loads.

It is clear that it will be essential to develop new thermal power sources, namely, one 200 MW class unit by fiscal 1992 at the latest, and two subsequent 200 MW class units by fiscal 1993 and 1994.

(2) The results of the fact-finding investigation of the structure of power demand situation mentioned in the previous paragraph indicate that it will be essential to develop new base load power sources to secure power supply capability corresponding to increasing power demands.

In view of the fact that KESC has no appropriate hydro-electric power source development site, the types of power sources to be developed are limited to thermal power sources. In case of thermal power generation, it will be possible to search for economically optimum power plant operation through careful selection and diversification of fuels to be used. A review of all the conditions, however, indicates that oil-fired high efficiency thermal power units should be selected.

The reason is; although natural resources, such as natural gas, coal, oil and so forth, are expected to be available for energy sources for thermal power generation in Pakistan, the development speeds of these natural resources are rather slow. Consequently, it has been judged to be impossible to relay on the domestic Production of energy resources as fuels for large-scale thermal power units in the near future.

Therefore, as the fuel for such large scale thermal power units, heavy oil should be chosen due to its reliable supply, though it may have to be imported.

Due to aging, the West Wharf Thermal Power Plant has shown a sharp decline in efficiency while its maintenance and operation costs have risen. Therefore, it would be advantageous for KESC to decommission the existing units as early as possible and replace them with high efficiency thermal power units having a capacity as large as possible to serve as a base load power plant.

(3) It is technically and economically desirable to locate power sources close to the demand area. When power sources have to be located far apart from the demand area, it is necessary to improve the reliability of power system operation by interconnecting dispersed power sources by powerful trunk transmission lines.

From a long-term point of view, it is necessary to reinforce interconnections of these trunk transmission lines and improve the stability of the power systems by constructing formation of a powerful outer loop surrounding the demand center. This would ensure flexibility in site selection of new power sources and improve the reliability of power supply in response to the growth of demand in the demand center.

Regarding the configuration of the power sources of KESC at the time of this study, the Bin Qasim Thermal Power Plant, Korangi Thermal Power Plant and other large capacity thermal power sources occupying more than 85% of its system capacity are located only on the east side of Karachi. The majority of this power output is transmitted to the load center on the west side of Karachi. Only about 10 percent of the total system capacity is supplied from the West Wharf Thermal Power Plant and the Karachi Nuclear Power Plant (KANUPP). Thus, the power flow is extremely one-sided-toward the west side from the east side.

Therefore, connecting a new large-scale power source to the power system on the west side will contribute to an improvement of the power flow situation.

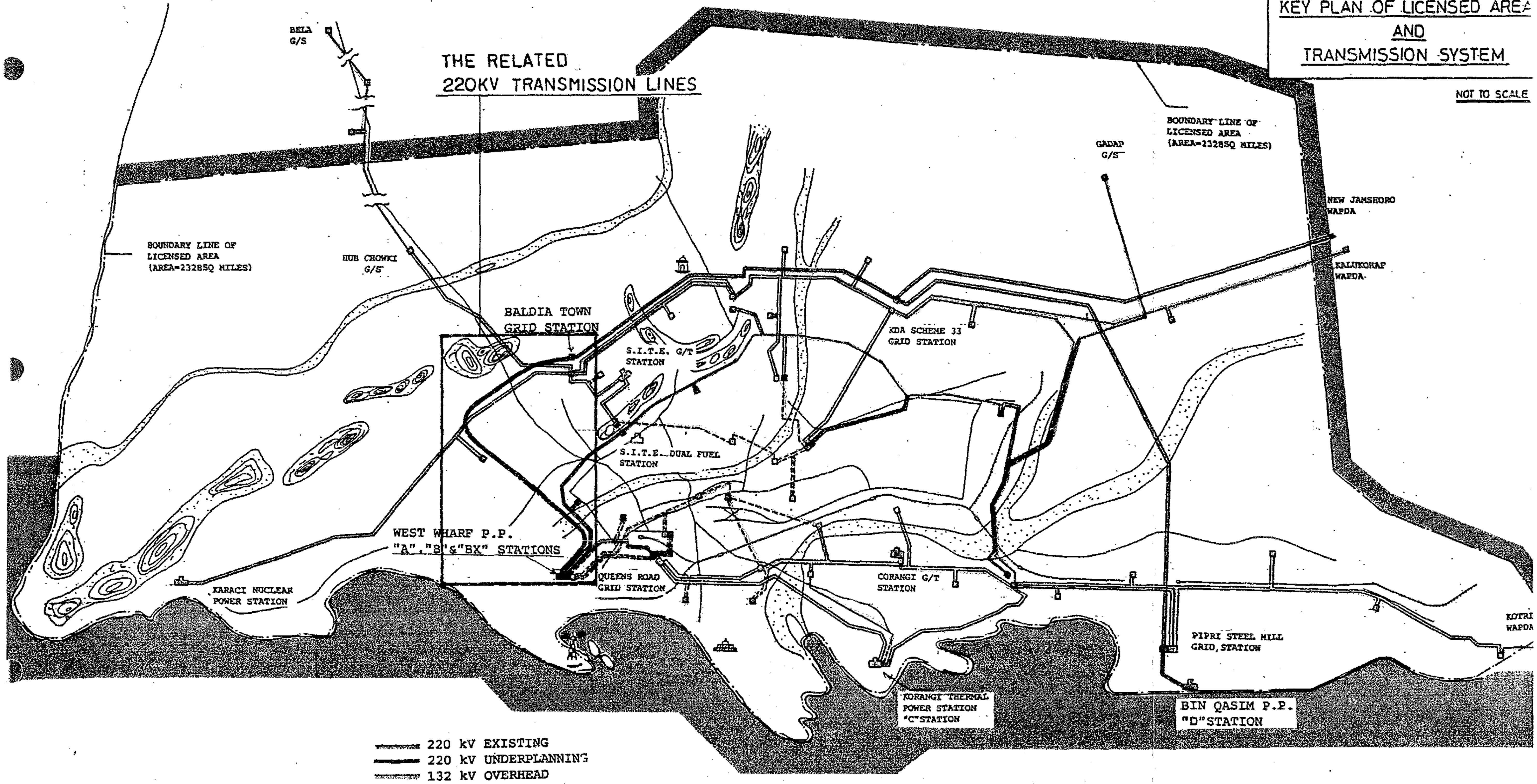
If power output from the West Wharf Power Plant were to be transmitted to the 220 kV trunk transmission line which has been constructed up to the Baldia Grid Station in the outskirts of Karachi, this would make it possible to realize the formation of a powerful outer loop surrounding the load center of Karachi. In this way, the reliability and effective system operation of the KESC power system could be substantially improved.

WEST WHARF THERMAL POWER PLANT PROJECT
RELATED 220KV TRANSMISSION LINES

P & D No: 898-F-I | MP-EST/75-
DATED 25.4.1987

KEY PLAN OF LICENSED AREA AND TRANSMISSION SYSTEM

NOT TO SCALE



220 kV EXISTING
220 kV UNDERPLANNING
132 kV OVERHEAD
132 kV UNDERGROUND
66 kV OVERHEAD
66 kV UNDERGROUND

INCLUDING PROJECT PROPOSED IN SIXTH FIVE YEAR PLAN AND SEVENTH FIVE YEAR PLAN

1.3 Selection of the Optimum Development Plan

According to the Basic Plan of the Project, it will be essential to develop one (1) 200 MW class unit by fiscal 1992 at the latest, and two (2) subsequent 200 MW class units by fiscal 1994.

It is concluded that it is desirable to construct as large as possible capacity units in the West Wharf Power Plant, in view of the KESC power system operation and the increasing power demands. Because the site has only limited space and other restricting factors, regarding cooling water, fuel availability, environmental impacts, etc., the following three development plans were selected as comparative plans considering KESC's intentions.

Plan 1 Two (2) sets of 200 MW oil fired thermal power generating unit

Plan 2 One (1) set of 300 MW oil fired thermal power generating unit

Plan 3 One (1) set of 300 MW combined cycle unit

Among these three plans, two (2) 200 MW thermal power generating units are recommended as being the most preferable for this project.

One (1) of 300 MW unit (Plan 2) seems preferable in view of cost effectiveness (scale merit) and its large capacity to cope with the KESC power demand. However, it is not recommendable for KESC to have only one (1) large capacity unit in the West Wharf Power Plant in view of operation and maintenance problems, such as plant outage due to annual inspection and/or forced outage, etc.

Plan 3, one (1) set of 300 MW combined cycle unit, has been evaluated as not being very economical, due to relatively higher fuel prices, and was not recommended due to the difficulty of fuel supply and complexity of maintenance and operation.

Main equipment specifications and the study results of the related facilities of the optimum development plan are as described below.

(1) Plant specifications

200 MW oil-fired thermal power plant — Two (2) sets

(2) Equipment specifications

i) Steam generator

Type	Outdoor type, reheat, pressurized furnace, oil/gas fired, top supported boiler

ii) Steam turbine

Type	Reheat condensing tandem-compound double flow turbine
Rated output	200 MW (at 65 mmHg.abs. 0% make-up)
Steam condition	Main steam pressure 169 kg/cm2g Main/reheat steam temperature 538/538°C

iii) Generator

Type	Horizontal type, totally enclosed synchronous machine
Cooling method	
Stator	Water cooled
Rotor	H2 gas cooled
Power factor	0.85
Frequency	50 Hz
Speed	3,000 rpm

(3) Related Transmission and Substation Facilities

KESC transmission lines presently comprise 220 kV, 132 kV and 66 kV lines.

220 kV lines are the principal transmission lines and, at present, transmit power from the Bin Qasim Power Plant to the KESC region via a route surrounding the Karachi area, ending at the Baldia Grid Station.

In order to realize the optimum power transmission and substation system with the new West Wharf Power Plant, the study team performed power flow study and stability analysis of the KESC power system, based upon the system configurations before and after completion of the development plan.

From study results, it has been judged that to construct the new West Wharf Power Plant with two (2) circuits of 220 kV transmission line (24 km) to Baldia G/S is the best plan for the project.

The new transmission and facilities related to the Development Plan, connecting the West Wharf Power Plant on the west side of the KESC system to the Bin Qasim Power Plant on the east side, will realize a powerful outer loop surrounding Karachi City, and will enable improvement of system reliability and stability with better balancing of the power generating sources on both sides of the KESC network system.

(4) Auxiliary Facilities

i) Fuel Transportation and Storage

Adoption of heavy oil and natural gas as the fuels of the new West Wharf Power Plant has been studied.

Two (2) tanks, having a capacity of 19,689 kl and 6,351 kl, exist in the CALTEX area, and are located in an adjacent area north of the site.
An oil supply line, having a capacity of 120 m3/hr, exists from the CALTEX East Wharf storage area to the site, thus enabling sufficient supply for two (2) sets of 200 MW oil fired thermal power generating units.

As for natural gas, the existing gas receiving facilities will be used.

The capacity of the existing natural gas is 10 MMCFD (10 x 10^6 ft^3/day), and is sufficient for auxiliary fuel supply to a 200 MW class thermal power unit for start up and low load unit operation.

ii) Cooling Water Lines

Intake line

Two methods for supplying condenser cooling water to the new power generation units are studied comparatively.

One is to use the existing intake facilities, composed of one line box culvert and three lines of concrete pipes; the other is to construct new water lines for the new units.

The latter plan, that is, to construct the portion of the intake facilities outside the plant site, is disadvantageous economically. It necessitates high technology as compared with the former, because it would require modification of an intake openning on the quay and construction of new water ways across the wharf of the Karachis Port Trust from east to west. Other problems include cargo handling operations, etc.

The capacity of the existing intake water lines, including the box culvert which was constructed for future use, were evaluated and found to be sufficient for providing enough water to two (2) sets of 200 MW thermal power units.

As a result of survey, these facilities are applicable to the new plant, judging from the investigation results of their soundness, though some repairs may be required.

Discharge line

Two (2) methods for establish cooling water discharge line are investigated.

One is to construct new discharge channels, and the other is to utilize the existing discharge channels.

However, in the latter case, it is necessary to expand the existing facilities due to insufficient capacity. However, as this modification is unrealistic, the plan for effective utilization of the existing discharge facilities is discarded as not being infeasible.

KESC had asked Karachi Shipyard Engineering and Works to use their premises for constructing and installing the new cooling water discharge line(s), and KSY has basically agreed to this request.

1.4 Development Procedure for W.W.1 and W.W.2

1.4.1 Development Procedure for W.W.1

Making use of the most efficient procedure in the development project was a very important subject considered by the JICA study team. The team studied the problem of how to achieve early decommissioning or dismantling of generating power stations "B" and "BX", and how to construct new units having a maximum generating capacity in the limited area in accordance with the planned implementation schedule.

It is desirable to stop operation of the existing "BX" Station in order to implement the West Wharf Thermal Power Plant Project as scheduled and without any undue difficulties. However, early decommissioning and retirement of the "BX" Station seemed to be impossible, as KESC's intention, because this station supplies power through an 11 kV distribution system to important facilities in the West Wharf area such as the Karachi Shipyard, the Naval Yard and the Karachi Port Trust.

In order to solve this problem, the study team considered the possibility of early dismantling of the "BX" Station so as to start construction work of the new plants at the same time. This was studied from the viewpoints of economical and effective construction work and improvement of demand and power in the KESC system.

To achieve this, power should be continuously supplied to the 11 kV distribution system by receiving power from outside the plant, or setting up alternative generating facilities, such as gas turbines or diesel generators.

To reinforce transmission lines, KESC worked out its sixth five-year plan (1983-1987) and a seventh five year plan (1988-1992).

It is difficult, however, to ensure stable power supply to those important facilities without the "BX" Station due to the restricted time for loan arrangements and for obtaining land for installation of the transmission lines.

It was also concluded that it would be difficult to install temporary generating equipment in the space occupied by the "B" Station facilities, as these facilities are used in common with the "BX" Station which is now in operation.

After taking into account KESC's intentions, the study team consequently decided upon recommending the following procedure:

The first new unit could be constructed in the site of the already dismantled "A" Station, while operation of the "BX" station should continue.

1.4.2 Construction Procedure for W.W.2

It is difficult to stop operation of the "BX" Station under the present KESC electric supply status.

The second unit can be constructed in the site of the existing "B" and "BX" Stations after they are dismantled. The decommissioning of these stations could proceed after power is received from the 220 kV transmission lines set up as part of the project.

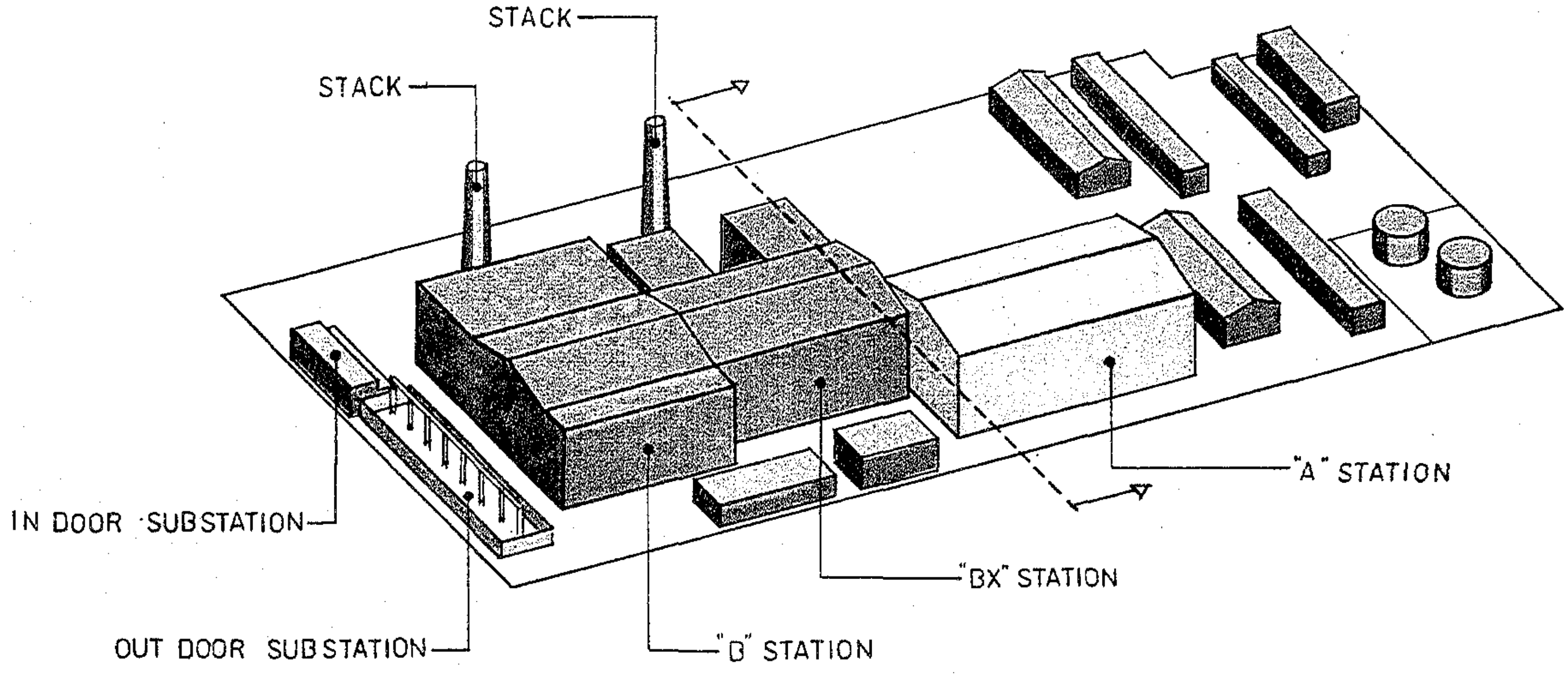
If the "BX" Station is kept in operation until the commissioning time of W.W.1, selection of and contract negotiations with another contractor for the second unit will delay the completion date of W.W.2 by about three (3) or four (4) years. There is also the problem of the dismantling period of the "BX" Station to cope with.

As a solution to this problem, it would be better to complete the 220 kV transmission lines as early as possible in order to achieve early decommissioning of the "BX" Station. If the construction work, including dismantling of the existing power plant, is carried out by the same contractor and both units are arranged in the same package of the loan agreement, the completion date of W.W.2 can be realized two (2) years after completion of W.W.1. (Refer to Implimentation Schedule, Fig. 1-2).

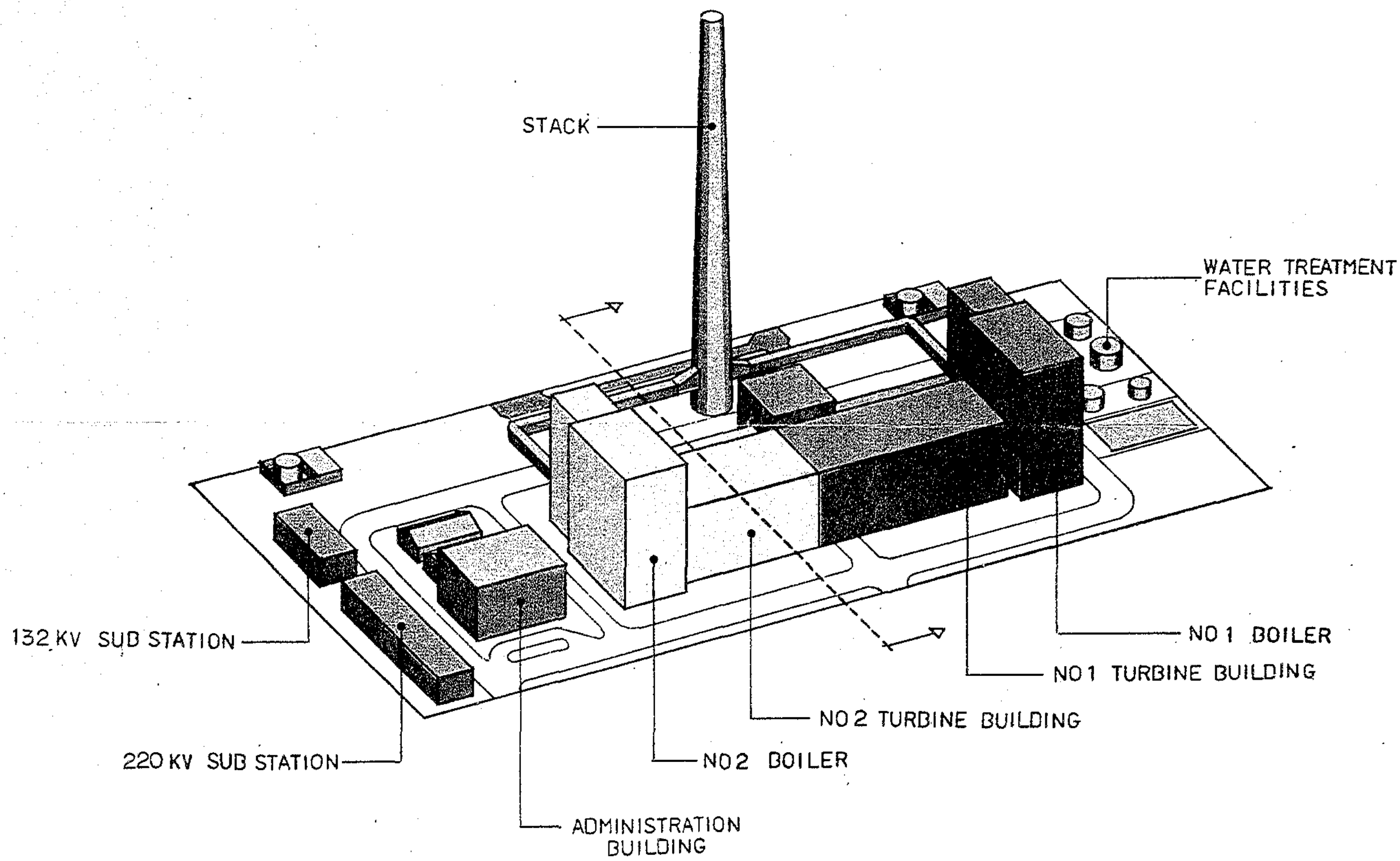
The completion time of W.W.1 is expected by the end of 1992, with that of W.W.2 by the end of 1994.

KESC WEST WHARF THERMAL POWER PLANT

EXISTING POWER PLANT



DEVELOPMENT PLAN
2×200MW OIL FIRED THERMAL POWER UNITS



1.5 Implementation Schedule

The implementation schedule for the optimum development plan, that is, the first unit of 200 MW thermal power plant, is envisaged to be completed at the end of 1992, with that of the second unit at the end of 1994, which is two years after completion of the first unit. The construction period is planned for 36 months for the first unit and 32 months for the second unit, including dismantling of "B" and "BX" Stations. Note, however, that this is on the condition that the construction work is executed by one contractor.

Construction Schedule Key Dates:

(1)	Detailed Design Completion	Jan., 1989
(2)	Contract with Erector	Oct., 1989
(3)	Construction Start	Nov., 1989
(4)	220 kV Transmission Line Completion	Jan., 1992
(5)	Start of Dismantling Work of "B" and "BX" Stations	Feb., 1992
(6)	First Unit Commissioning	Oct., 1992
(7)	Second Unit Commissioning	Oct., 1994

1.6 Construction Cost

Based upon the optimum development plan and equipment specifications (Refer to previous section 1.3), the construction cost for 2 sets of 200 MW thermal power generating units and 220 kV transmission and substation facilities has been estimated.

These costs have been estimated based on the average costs in Japan, with reference of tender prices of the similar equipment in Pakistan, local material costs, local labour costs, etc. Furthermore, it considers additional costs due to reconstruction of the existing power stations, such as dismantling of the "B" and "BX" Stations, removal and rebuilding of the existing facilities, etc.

The estimated construction costs are summarized as follows.

(1) Construction Cost of West Wharf Thermal Power Plant Units 1 and 2

	Japanese Yen	Equivalent Rupee
<u>Foreign Currency</u>	<u>38,072.78 x 10^6¥</u>	
Items		
200 MW power equipment, 2 sets	27,900.00 x 10^6¥	
Civil works	4,293.00 x 10^6¥	
Substation	2,520.00 x 10^6¥	
Consultant fee & contingency (%)	<u>3,359.78 x 10^6¥</u>	
	38,072.78	
<u>Local Currency</u>	<u>7,529.87 x 10 ¥</u>	<u>1,016.53 x 10^6Rs</u>
Items		
200 MW power equipment, 2 sets, erection fee	2,565.00 x 10^6¥	346.27 x 10^6
Civil works	3,114.50 x 10^6¥	420.46 x 10^6
Substation, erection fee	68.00 x 10^6¥	9.18 x 10^6
Consultant fee & contingency	<u>1,782.37 x 10^6¥</u>	<u>240.62 x 10^6</u>
	7,529.87 x 10^6¥	1,016.53 x 10^6

(2) Construction Cost of 220 kV Transmission and Substation Facilities

Foreign currency (equipment, material)	$2,203.0 \times 10^6$¥	
Local currency (erection)	585.9×10^6¥	79.1×10^6Rs

(3) Total

Foreign currency	$40,275.78 \times 10^6$¥
Local currency	$8,115.77 \times 10^6$¥

1.7 Economic and Financial Evaluation

Financial and economic evaluation of the two (2) sets of 200 MW class thermal power generating units with associated 220 kV transmission and substation facilities of the project has been performed.

The criterion used in this appraisal is the Internal Rate of Return for the power benefits expressed in terms of sales prices of energy.

Financial projections are made in line with KESC's formula, and the figures adopted as Assumption Basis were settled according to KESC's instructions.

In this evaluation, the construction costs of the project and the fuel price have been estimated as constant values, as these are the important basic figures. According to this assumption, financial evaluation, to estimate FIRR, could be performed by considering the sales prices of electric power only, as variable figures.

The Economic Internal Rate of Return (EIRR) of the project from the viewpoint of the Pakistan national economy was calculated by applying economic costs instead of the financial costs used in the financial analysis.

The economic cost of the project was prepared by deducting the transfer components within the economy, such as Import Duty and Agency Commission, etc.

The results of the financial and economic evaluation are listed below, and leads to the conclusion that the present project is feasible by these evaluations.

	Base Rate Fixed at Paisa 113.65/kWh	Increase of Base Rate Assumed
Financial Internal Rate of Return	14.0%	17.3%
Economic Internal Rate of Return	19.9%	24.0%

1.8 Conclusion and Recommendations of Project

The JICA study team carried out feasibility study on the thermal power development plan for the West Wharf Thermal Power Plant for the period from November 1987 to May 1988.

During this period, reference data and information were collected for carrying out the study and analysis so as to determine the optimum development plan for this project. Based on the results of the study, the JICA study team presents the following conclusion and recommendations.

1. Large capacity power plants will be required to meet the increasing power needs of Karachi City, with construction realized as soon as possible in view of the power shortage estimated to occur in 1992.

2. Two (2) sets of oil fired thermal power plants, each having a generating capacity of 200 MW, are most desirable economically and technically.

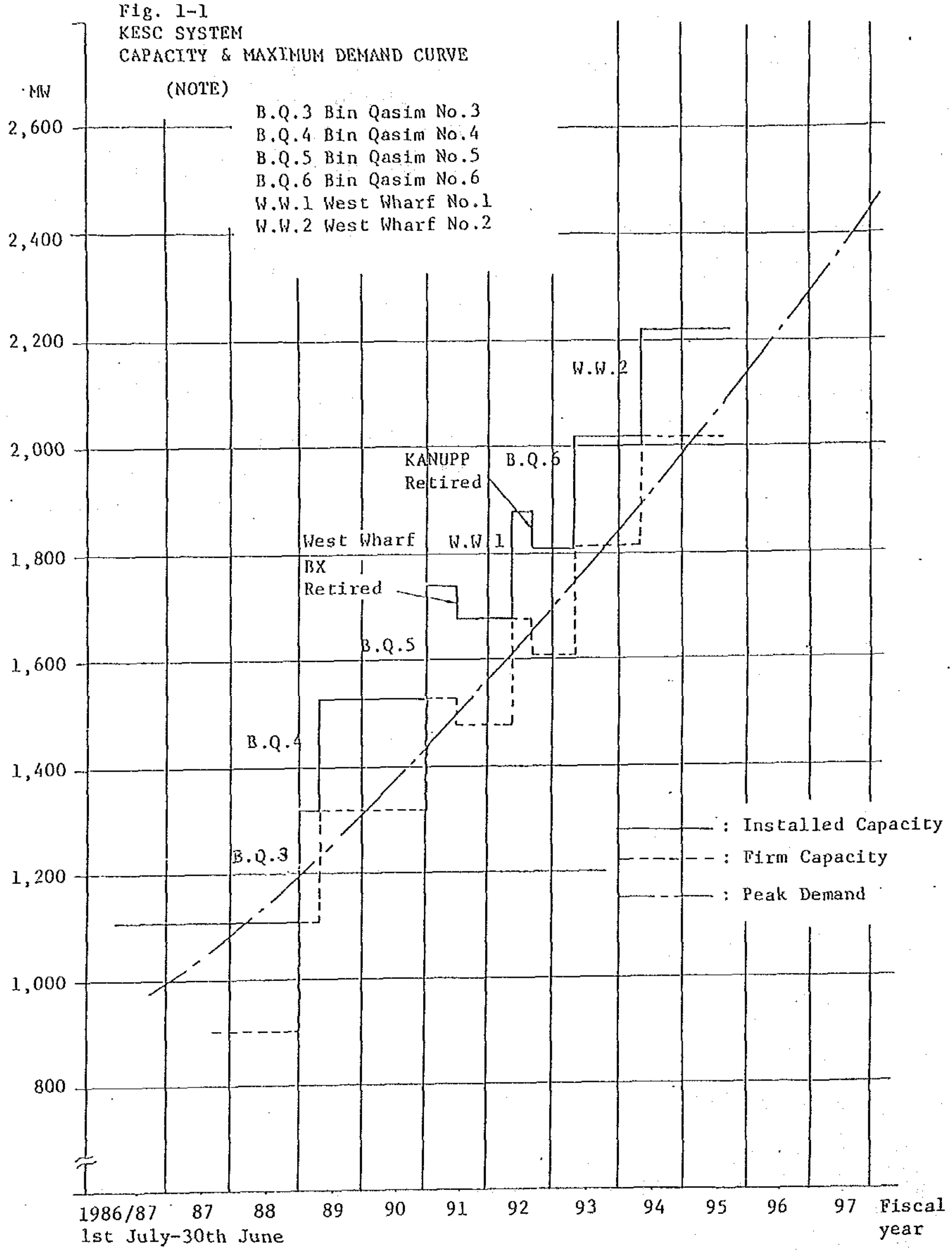
3. The project implementation schedule envisages the expected completion data for the first unit at the end of 1992 and that of the second unit at the end of 1994.

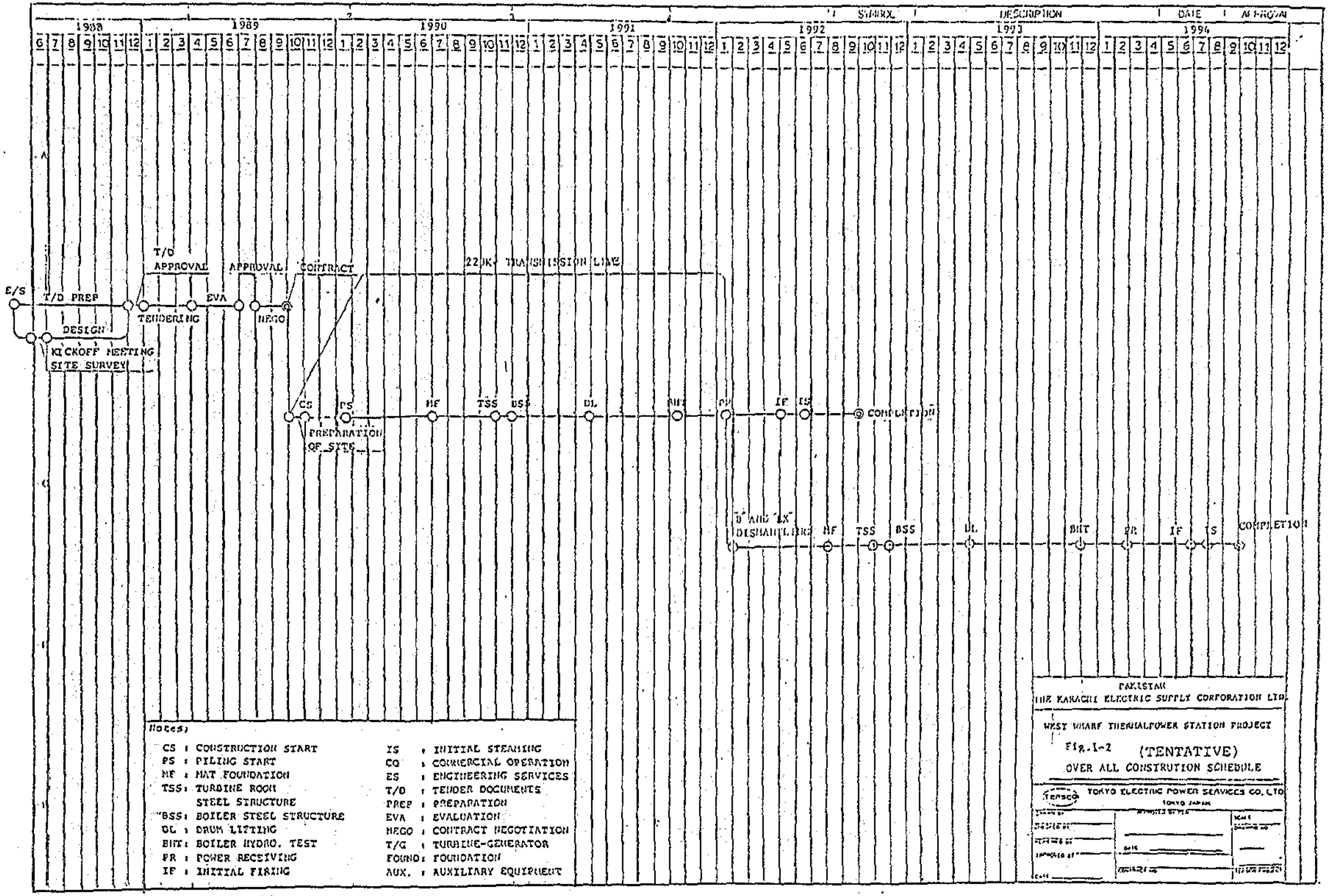
4. Provision of 220 kV transmission lines and related facilities will be required to improve the reliability and stability of KESC transmission networks by the beginning of 1992.

5. Construction cost of the project is estimated tentatively as follows.

(1)	Power Plant Equipment	Foreign Currency 38,100 Million ¥ Local Currency 1,017 Million Rs. (7,500 Million ¥)
(2)	Transmission Line and Related Facilities	Foreign Currency 2,200 Million ¥ Local Currency 79 Million Rs. (586 Million ¥)
(3)	Total	Foreign Currency 40,276 Million ¥ Local Currency 1,096 Million Rs. (8,116 Million ¥)

Fig. 1-1
KESC SYSTEM
CAPACITY & MAXIMUM DEMAND CURVE




1988
1989
1990
1991
1992
1993
1994
REMARK
DESCRIPTION
DATE
APPROVAL
E/S
T/D PREP
DESIGN
KICKOFF MEETING
SITE SURVEY
T/D APPROVAL
TENDERING
EVA
APPROVAL
NEGO
CONTRACT
22 KV TRANSMISSION LINE
CS
PS
PREPARATION OF SITE
MF
TSS
BSS
DL
BHT
PR
IF
IS
COMPLETION
"D" AND "EX" DISMANTLING
Notes;
CS : CONSTRUCTION START
PS : PILING START
MF : MAT FOUNDATION
TSS: TURBINE ROOM STEEL STRUCTURE
BSS: BOILER STEEL STRUCTURE
DL : DRUM LIFTING
BHT: BOILER HYDRO. TEST
PR : POWER RECEIVING
IF : INITIAL FIRING
IS : INITIAL STEAMING
CO : COMMERCIAL OPERATION
ES : ENGINEERING SERVICES
T/D : TENDER DOCUMENTS
PREP : PREPARATION
EVA : EVALUATION
NEGO : CONTRACT NEGOTIATION
T/G : TURBINE-GENERATOR
FOUND: FOUNDATION
AUX. : AUXILIARY EQUIPMENT
PAKISTAN
THE KARACHI ELECTRIC SUPPLY CORPORATION LTD.
WEST WHARF THERMALPOWER STATION PROJECT
Fig.1-2 (TENTATIVE)
OVER ALL CONSTRUTION SCHEDULE
TEPSCO
TOKYO ELECTRIC POWER SERVICES CO.,LTD.
TOKYO JAPAN

APPENDIX

TRANSITION AND PRESENT SITUATIONS OF WEST WHARF THERMAL POWER STATION

1. Transition and Present Situations of West Wharf Thermal Power Station

The West Wharf Thermal Power Station is comprised of the "A" Station, "B" Station and "BX" Station equipment.

Starting from Unit No. 1 commissioned in 1946, the "A" Station comprises five turbine generator units and nine boiler units having a total output of 10 MW. It was completed in 1953.

The "B" Station comprises two turbine generator units and three boilers having a total output of 30 MW (15 MW x 2). It was commissioned in 1956.

The "BX" Station comrises two turbine generator units and two boilers having a total output of 66 MW (33 MW x 2). It was commissioned in 1962.

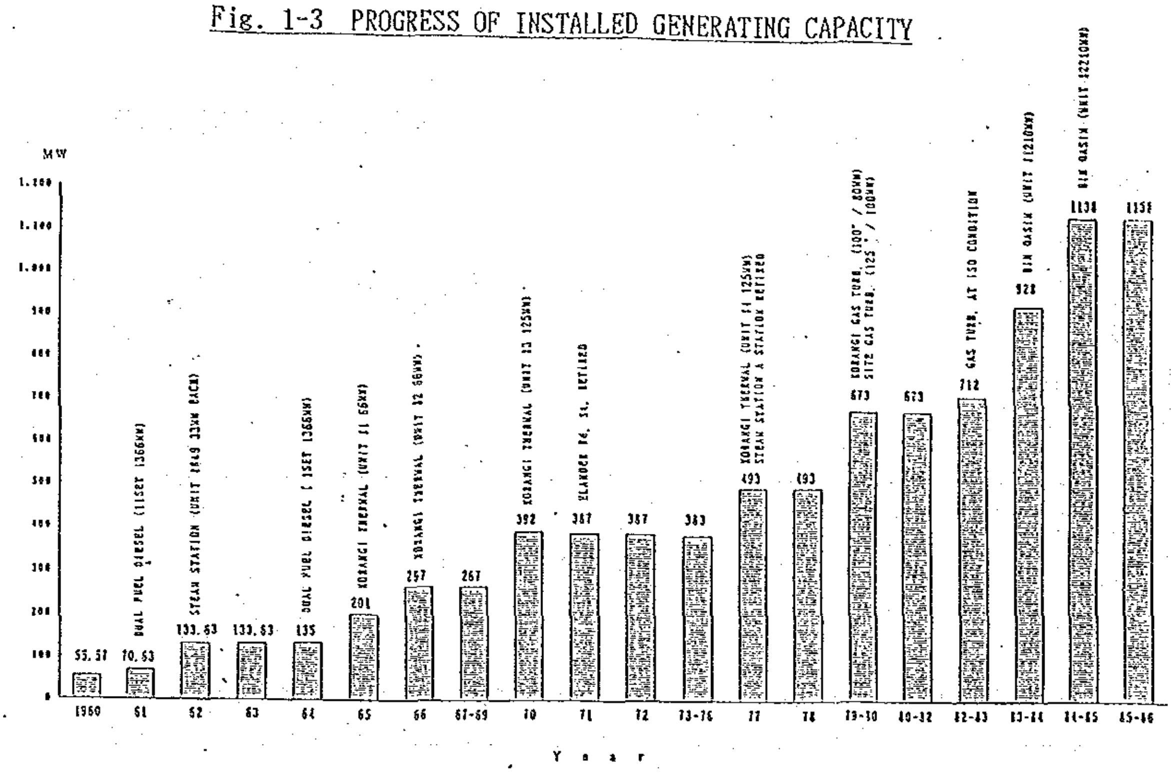
The "BX" Station, consisting of one boiler per one turbine generator unit, was commissioned as a modern power plant whose configuration is not different from that of the existing power plant equipment in Japan.

The above respective power station units were designed to permit dual-firing of heavy oil and gas as fuels.

As a result of completion of the "BX" Station, the total output of the West Wharf Power Station reached 106 MW, and the power station had been playing a major role by sharing about 28% of the total available output of KESC, amounting to 383 MW in the earlier half of 1960s.

The transition of the total available power output of KESC is as shown in Fig. 1-3.

Fig. 1-3 PROGRESS OF INSTALLED GENERATING CAPACITY



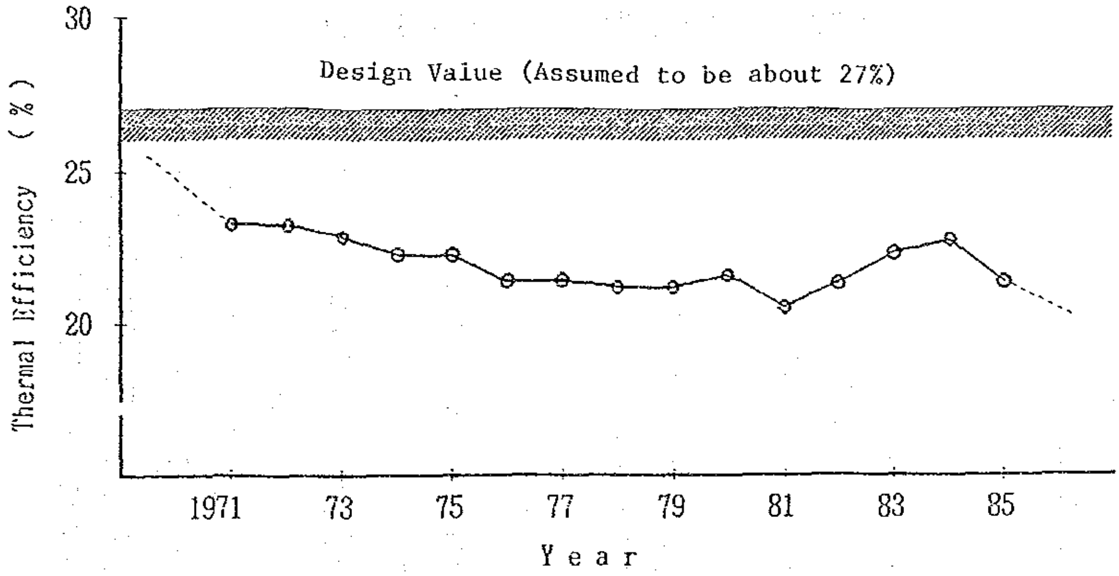
(出典) KESC Statistical Report

In the latter half of 1970s, a large scale thermal power source (Korangi Thermal Power Plant Unit No. 4: 125 MW) was commissioned in response to the need for a large capacity power source in compliance with the growth of electric power demand. However, the "A" Station was shut down in 1977.

In this era (1970s), the thermal efficiency of the "B" and "BX" Stations had been lowered by 4 to 5% below the design values (estimated to be about 27%) due to deterioration of equipment which had been in continuous operation 15 or 20 years subsequent to commissioning of these units.

The transision of thermal efficiency is as presented in Fig. 1-4.

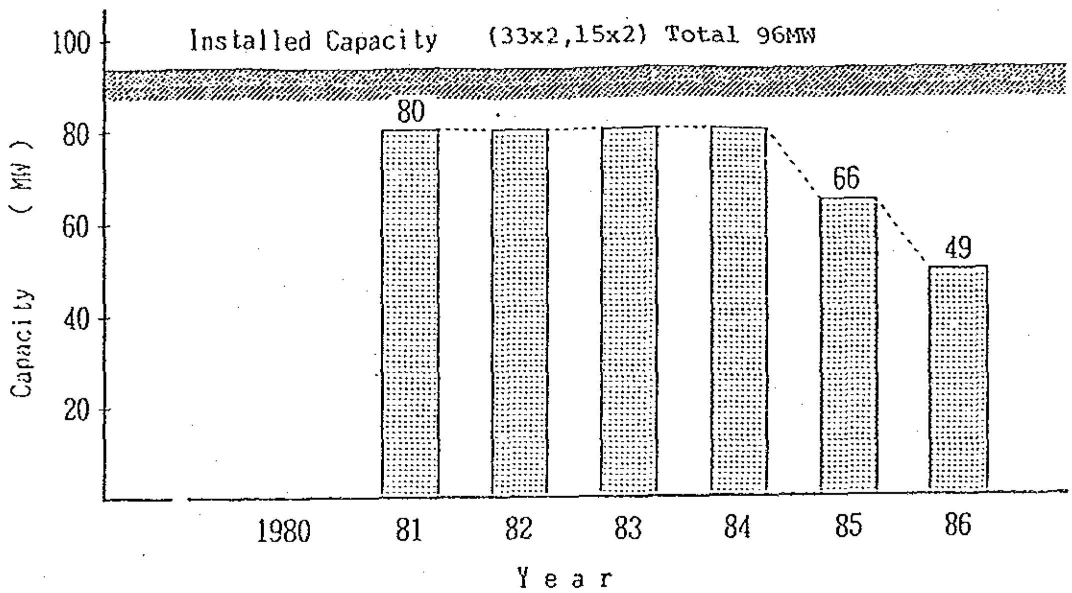
Fig. 1-4 Transition of Thermal Efficiency



As indicated in Fig. 1-3, large capacity thermal power plants have been commissioned one after another since the latter half of 1970s. Thereby, the leading position of the West Wharf Thermal Power Station among those in the entire power system of KESC had come to be replaced by other large scale and modern power plants. In recent years, the output of the power station is actually only 49 MW, or about 4%, of the total available output of KESC.

The transition of actual capacity (reduction of power output) of this power station is as indicated in Fig. 1-5.

Fig. 1-5 Transition of Actual Capacity



The rapid reduction of actual power output from 1984 through 1986 is assumed to have resulted from shutdown of the "B" Station. However, the actual output of the "BX" Station is clarified to have been lowered to about 50 MW from its available output of 66 MW.

This reduction of output is considered to have been caused by the reduction efficiency of the feedwater pump and thermal efficiency of the boiler. Although efforts have been made to recover the efficiency and output through maintenance of equipment during scheduled shutdown for maintenance and inspection, this objective has not yet been achieved.

Chapter 2. OUTLINE OF PAKISTAN

2.1 Outline of Investigation Area

2.1.1 Land and geographical conditions

The Islamic Republic of Pakistan became an independent nation on August 14, 1947.

Located between Lat. 24° - 31°N and Long. 61° - 77°E, Pakistan extends some 1,500 km in length in its northeastern direction, and has an approximate 800 km long coast line facing the Arabian Sea.

The country adjoins Iran to the west, Afganistan to the north and northwest, China to the northeast, and India to the east and southeast.

With a total area of about 804,000 km2, Pakistan is geographically comprised of the five main zones: (1) Northern mountain zone; (2) Western mountain zone; (3) Baluchistan Plain; (4) Potwar Plain and Salt Range; and (5) Indus River basin plain.

Karachi City, in which the West Wharf Power Plant is located, belongs to an administrative region of Sind Province situated in the downstream basin of the Indus River.

2.1.2 Climate

Since Pakistan is generally located in a dry semitropical zone, the ambient temperature becomes extremely high in summer, though the climate is cool and comfortable in winter. Precipitation varies according to district, with an annual average of 1,500 mm of rain in the mountainous area of Punjab State during the monsoon season (July - September). However, the annual average rainfall of 250 mm or less is recorded in more than three-fourths of the country.

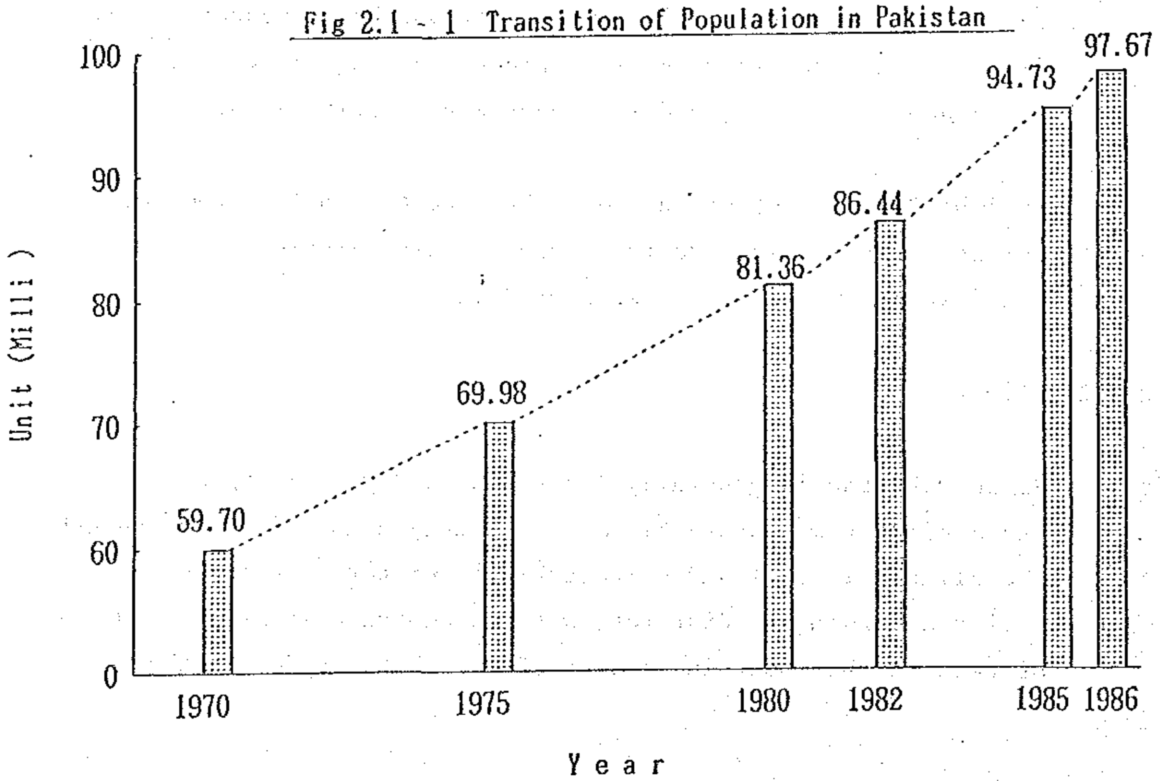
The average number of rainfall days is roughly ten or so in Karach City, with almost no rainfall recorded in 1985 through 1987.

Due to the effect of the Arabian Sea, however, the humidity in Karachi City is higher than that in other cities of the country, and the mean air temperature even in the extremely hot season (April - June) is a moderate 30° - 31°C.

2.1.3 Population

The population in Pakistan is estimated to be nearly 100 million at present (1988). The transition of the population is indicated in Fig. 2.1-1.

Fig 2.1 - 1 Transition of Population in Pakistan



(Source: From Economic Survey 1985 - 1986)

Moreover, the statistics in "the Housing Population Census 1981/82" executed by the Government of Pakistan is indicated in Table 2.1-1.

Table 2.1-1 Transition of population in major cities (1921 - 1981)

Census years / Cities		1921	1931	1941	1951	1961	1972	1981	Annual average growth rate from 1951-1981 (%)
1.	Karachi	24.4	30.1	43.6	106.8	191.3	351.5	520.8	5.3
2.	Lahore	28.2	43.0	67.2	84.9	129.6	217.0	295.3	4.2
3.	Faisalabad	2.8	4.3	7.0	17.9	42.5	82.3	110.4	6.2
4.	Rawalpindi	10.1	11.9	18.5	23.7	34.0	61.5	79.5	4.2
5.	Hyderabad	8.2	10.2	13.5	24.2	43.5	62.9	75.2	4.0
6.	Multan	8.5	11.9	14.3	19.0	35.8	53.9	73.2	4.6
7.	Gujranwala	3.8	5.9	8.5	12.1	19.6	32.4	60.1	5.5
8.	Peshawar	10.4	12.2	17.3	15.1	21.9	27.3	50.6	4.4
9.	Sialkot	7.1	10.1	13.9	16.8	16.4	20.4	30.2	1.9
10.	Quetta	1.8	2.7	3.6	7.8	12.9	20.0	29.1	4.5
11.	Sargodha	4.9	6.0	6.5	8.4	10.7	15.8	28.6	4.1
12.	Islamabad	-	-	-	-	-	7.7	20.4	-

(Source) From Housing and Population Census 1981/82, G.O.P.

Pakistan is a multi-ethnic country chiefly comprised of Punjabi, Baluch, Sindhi and Pathan with Islam as the state religion.

As shown in Fig. 2.1-1, the annual average growth rate of population in 1980s is roughly 3%.

In consideration that the increase of population directly causes a variety of social problems on education, housing, medical care, foodstuff and employment, it is of an urgent necessity for the country to restrict further growth of the population.

According to the 6th Five Year Program (1983 - 1987), it was envisaged to lower the increase rate of population to 2.6%. However, it would be difficult to attain this goal.

From the transition of population in Table 2.1-1, the growth rate in Karachi is substantially higher than the other districts.

This rapid increase of population is considered to have resulted mainly from the following reasons: Namely, the city had played a role of the industrial and commercial center as a capital city of a new country after independence in 1947 until the capital city was transferred to Islamabad, and the city received inflow of refugees from India and other countries.

The population of Karachi which was 5.2 million when the Housing Population Census was carried out in 1981 is estimated to exceed 7 million at present (1987) and the annual increase rate is assumed to exceed 6.0%.

As is observed from the average growth rate indicated in Table 2.1-1, moreover, the increase rate of population in urban areas tends to become increasingly higher than that in rural areas, and migration of population into urban areas is considered to be accelerated in the future as well. Thereby, the population in Karachi is estimated is estimated to exceed 10 million in the near future.

2.1.4 Labour Force

As shown in Table 2.1-2, the population of labour force in 1983 is 26 million, which is only 29% of the estimated total population of 89 million. The reason of such a low ratio of labour force population is basically that sufficient opportunities of employment have not been offered due to small scale economic activities of the country.

Moreover, the increase in the opportunity of education for younger generation and a social factor where the ratio of women's participation in the labour market has traditionally been low are considered to have combinedly caused such a low ratio of labour force population to the total population.

Table 2.1-2 Transition of working population
(1977/78 - 1982/83)

	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83
Working population (1 million)	22.22	22.93	23.68	24.45	25.24	26.06
Increase of population (1 million)	0.63	0.71	0.75	0.77	0.79	0.82
Growth rate of population (%)	2.9	3.2	3.3	3.3	3.2	3.3
Employment population (1 million)	21.84	22.54	23.13	23.81	24.50	25.21
Employment ratio (%)	98.3	98.3	97.7	97.4	97.1	96.7
Nominal productivity (Rs.)*1	590	651	748	851	965	1,055 *3
Net productivity (Rs.)*2	590	609	637	657	681	699 *3

(Source): Pakistan Economic Survey fo[r] respective fiscal years

1) GDP per capita per month
2) GDP per capita per month based on the price index in 1977/78
3) Estimated values

Judging from the increase rate of population, the current labour force population in 1988 is estimated to be about 30 million. Whether sufficient opportunities of employment can be offered to the labour force population or not in the future will depend largely on the expansion in the scale of the national economy through reinforcement of the foundation of industries in urban and rural areas and expansion of various associated industries in the future.

Judging from the growth rate of population, the working population is estimated to reach approximately 30 million in 1988. Whether sufficient employment opportunities will become available largely depends on the expansion of the national economy.

Considering that migration of population into city areas will continue further in the future as described in Paragraph 2.1.3 above, it is desired to increase employment opportunities in city areas.

Statistics of the working population according to industrial sectors is as indicated in Table 2.1-3.

Table 2.1-3 Statistics of working population according to industrial sectors

(Unit: 1,000 persons)

Industries	No. of employees (Estimated)	Ratio (%)	No. of employees (Estimated)	Ratio (%)	No. of employees (Estimated)	Ratio (%)	No. of employees (Estimated)	Ratio (%)	No. of employees (Estimated)	Ratio (%)	Growth rate (%) of employee during (1971/72 - 1984/85)
1. Agriculture, forestry & fishery	10,793	57.3	13,643	55.7	13,987	55.5	13,476	51.9	13,854	51.8	28
2. Mining and manufacturing	2,433	12.9	3,349	13.7	464	13.7	3,869	14.9	4,011	15.0	65
3. Electric power, gas and water service	70	0.4	122	0.5	126	0.5	1,819	0.7	1,871	0.7	105
4. Construction	642	3.4	1,025	4.2	1,054	4.2	1,408	5.7	1,551	5.8	142
5. Wholesale, retail, hotel, etc.	1,879	10.0	2,681	10.9	2,778	11.0	3,012	11.6	3,102	11.7	65
6. Transport, communication and warehousing	911	4.3	1,171	4.8	1,217	4.8	1,220	4.7	1,257	4.7	
7. Other services (Financing, insurance, real estate, etc.)	2,118	11.2	2,510	10.3	2,584	10.3	2,700	10.4	2,728	10.2	29
Total	18,846	100.0	24,501	100.0	25,211	110.0	25,967	100.0	26,746	100.0	42

(Source): Pakistan Economic Survey (1982/83)

2.1.5 Economy

(1) Economic structure

Regarding the industrial structure of Pakistan, the agricultural sector occupies about 30% of GDP, while the industrial sector occuplies only 17% of GDP (Refer to to Table 2.1-3).

Therefore, the transition of the agricultural production causes a greater impact upon the economy of the country.

The industrial sector is comprised chiefly of light industries such as food and agricultural product processing industries including cotton spinning industry using the products of agricultural sector as raw materials.

Table 2.1-3 Configuration of industrial sector-wise GDP
(Unit: Rp. 1 million, %)

	1970/71 (nominal)		1975/76 (nominal)		1983/84 (nominal)	
Agricultural, fisher and forestry	16,236	35.3	38,338	31.6	91,837	24.4
Mining	243	0.5	968	0.8	5,458	1.5
Manufacturing	7,570	16.6	20,054	16.5	75,061	20.0
Electricity, gas and water service	782	1.7	1,713	1.4	8,353	2.1
Construction	1,979	4.3	6,739	5.6	19,120	5.1
Wholesale and retail	6,806	14.9	18,321	15.1	61,036	16.2
Transportation, warehousing and communication	13,014	6.6	8,332	6.9	29,108	7.7
Finance, insurance and real estate	2,634	5.8	7,377	6.1	22,098	5.9
Service	3,475	7.6	10,085	8.3	31,172	8.3
Administration & defence	2,963	6.5	9,490	7.8	32,750	8.7
GDB (Element cost base)	45,702	100.0	121,423	100.0	375,693	100.0

(Source): From Annual Report 1983 - 1984, State of Bank of Pakistan
JETRO TRADE SERIES 1985

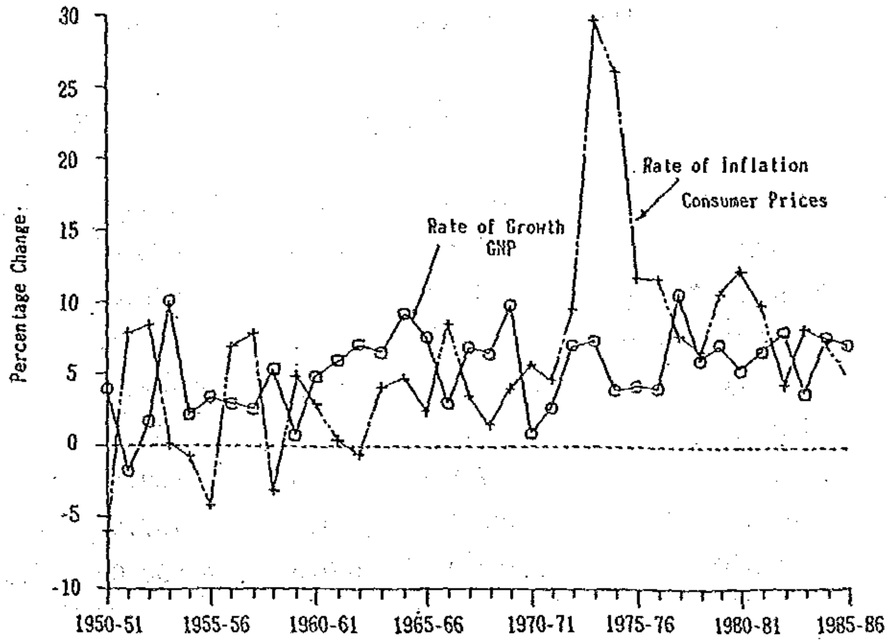
Note: The values for 1983/84 are tentative.

(2) Economic trend

As indicated in Fig. 2.1-4, the annual average economic growth rate in 1970/71 - 1976/77 was tended to be as low as 3.5%. However, the growth rate in the period from 1977/78 through 1985/86 exceeded 6% on an average.

However, the economy of the country has been experiencing various difficulties due to ever-increasing trade deficits, progress of inflation, decrease in the amount of remittance from the workers visiting the Middle East in search for job opportunities resulting from counter-oil-crisis.

Fig 2.1-4 Economic Growth and Inflation
1950 - 86



(Source): From Economic Survey 1985/86

According to the 6th five-year program (1983 - 1987) inaugurated/started in July 1983, it was envisaged to attain a target economic growth rate of 6.5%. In the final year of this program or 1987/88, the annual average growth rate of 6.5% is expected to be nearly attained (Refer to Fig, 2.1-4).

Among the total amount of investment from the Government sector under the 6th five-year program, 18%, 18% and 20% have been allocated respectively for the agricultural sector, transportation and communication sector and energy sector. From this fact, the government is considered to have strategically being directing its efforts for modernization and reinforcement of the agricultural and energy sectors (Refer to 2.1-5).

Table 2.1-5 Comparison of sector-wise investment under the 5th and 6th five-year programs

(Unit: Rs. 100 million)

	5th plan		6th plan	
Agriculture	374.5	15.8	897.2	18.1
Energy	393.9	16.6	1,000.0	20.2
Transportation & communication	468.2	19.8	896.2	18.1
Industry	458.0	19.3	769.1	15.6
Mining	7.4	0.3	60.5	1.2
Social	177.8	7.5	569.1	11.5
Others	490.2	20.7	757.9	15.3
Total	2,340.0	100.0	4,950.0	100.0

(SOURCE): From JETRO TRADE SERIES 1985

2.2 Electric Power Demand and Supply Situation

2.2.1 General Description

The natural energy resources available in Pakistan are oil, natural gas, coal and hydro-power sources. Among these resources, the hydro-power source is a prospective energy source in the future with potential capacity estimated to be about 36,000 MW. The capacity feasible economically for development is estimated to be 8,000 - 10,000 MW.

Hydro-electric power plants have been constructed in the Indus River and Jehlum River basins in the northern part of the country, which has a wealth of water resource.

At present, the installed capacity of hydro-electric power plants is about 2,900 MW. It accounts for about 44 percent of the total installed capacity in Pakistan.

In the case of hydro-electric power plants, there are problems such as reduction of power output due to drops in the water level in the dams in the dry season.

Electric power demand and supply of WAPDA in 1986/87 is presented in Fig. 2.2-1. Energy from hydro-electric and thermal power plants is similarly indicated in Fig. 2.2-2 (from WAPDA Annual Report 1986/87).

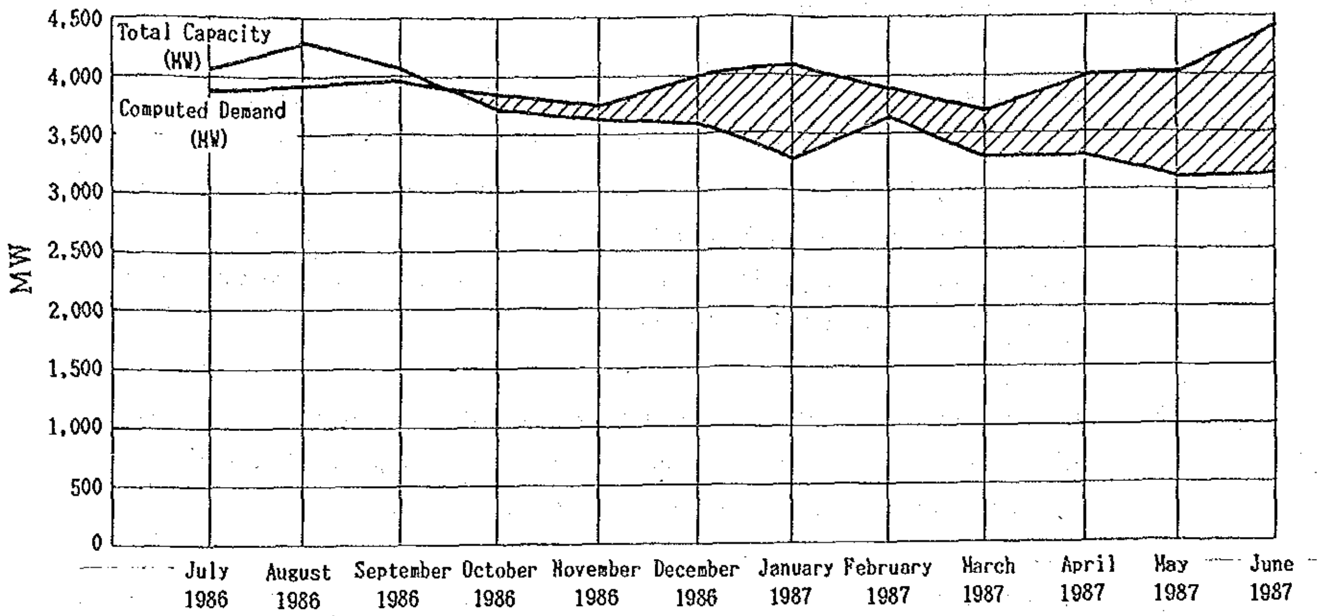
These diagrams indicate that the capacity of hydro-electric power plants is reduced due to drop of the water level in dry season and that the country experienced a power supply shortage of about 20 percent in May and June 1987.

The combined total installed capacity of thermal power plants of both WAPDA and KESC is about 3,600 MW. This accounts for about

Surplus Period

Deficit Period

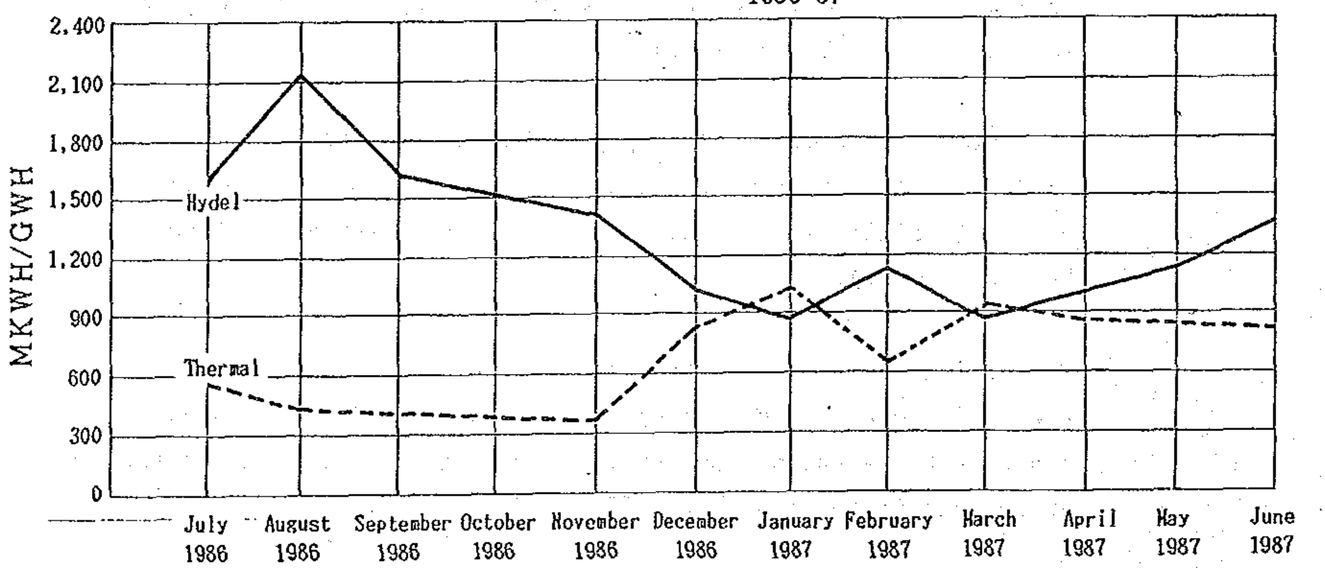
MONTH-WISE
Fig. 2.2-1 POWER CAPICITY-DEMAND (MW)
(SURPLUS/DEFICIT)
1986-87



Hydel

Thermal

MONTH-WISE
Fig. 2.2-2 POWER GENERATION (MKWH/GWH)
(HYDEL-THERMAL)
1986-87



54 percent of the total installed capacity.

The only coal-fired thermal power plant is the Quetta Thermal Power Station (15 MW) of WAPDA. The ratio of coal-fired units to other thermal power units is consequently very low.

Although natural gas was used initially as a major fuel for thermal power stations in Pakistan, the development of gas fields has not progressed in proportion to the growth of demand. As a result, the country has increasingly relied on oil fuels since the end of 1970s as electric power demand grew.

The electric power industry situation in Pakistan is serious, with substantial shortages of power occuring particularly in the dry season. When the high growth rate of electric power demand is taken into consideration, one sees that it is necessary to develop both hydro-electric and thermal power sources in the future.

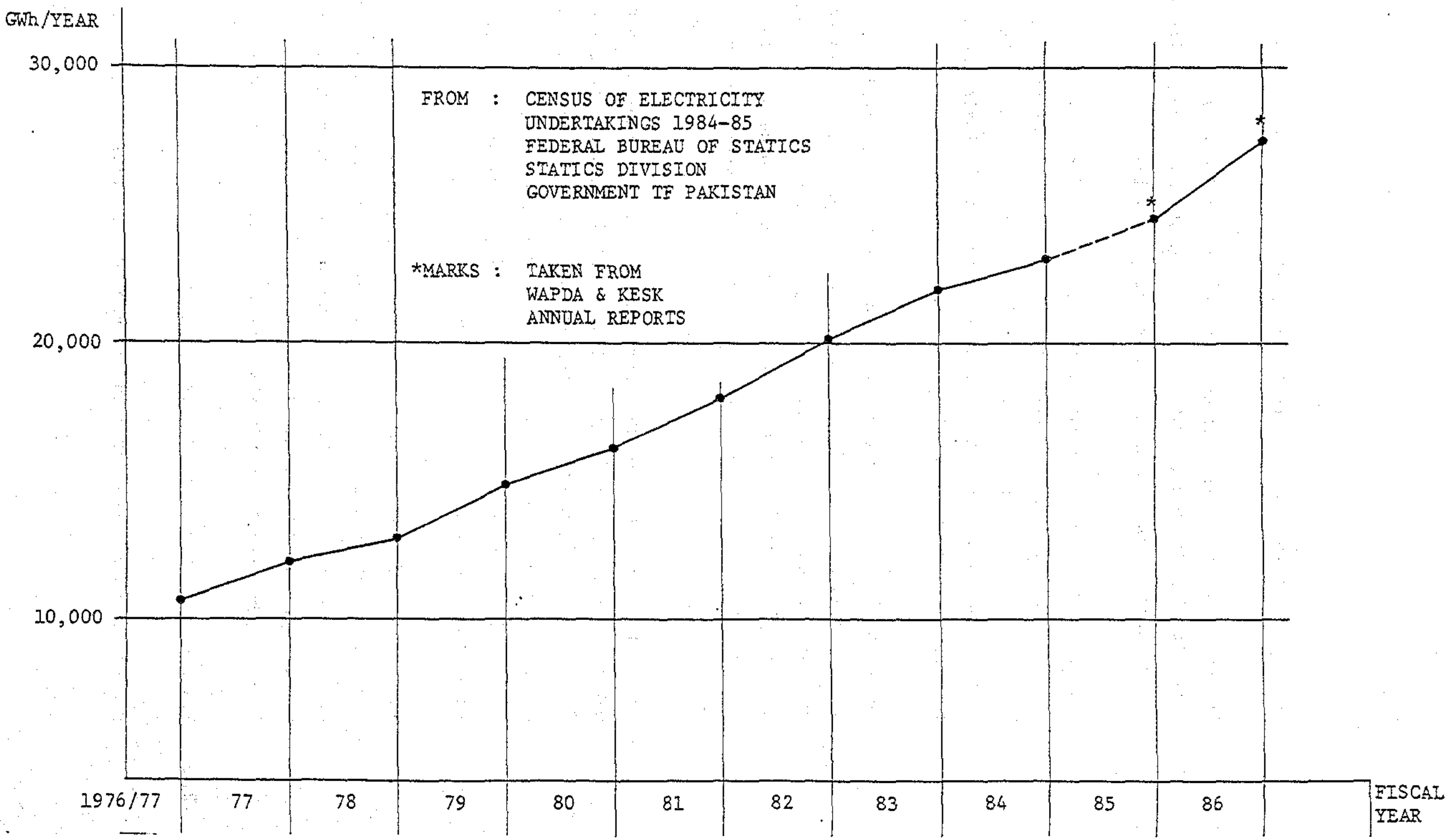
In an effort to overcome the shortage of electric power by 1990, WAPDA has been implementing development projects with the aim of commissioning 5,300 MW hydro-electric and thermal power sources by 1993. However, the tempo of these development projects is slowing down due to problems with financing, lack of consensus among state governments, and so forth.

In the case of KESC, which totally reles on thermal power sources, electric power demand is predicted to grow as much as 9 percent annually up to 1996/97. Therefore, KESC is planning to develop thermal power sources by constructing 200 MW class thermal power units successively for the next several years.

2.2.2 Transition of Generated Electrical Energy

Electrical energy generated in the past decade (1978 - 1988) in

Fig. 2.2-3 GENERATION OF ELECTRICITY
(1976/77 ~ 1986/87)



Pakistan is indicated in Fig. 2.2-3.

Presented also in Table 2.2-1 is the total generated electrical energy in 1986/87.

According to the above table, the total generated electrical energy is 29,053 GWh, comprised of 52 percent hydro-electric power, 46 percent thermal power and 2 percent nuclear power.

Table 2.2-1 Total generated electrical energy (1986/87)

(Unit: GWh)

	WAPDA	KESC	KANUPP	Total	Percentage
Hydro-power	15,251	-	-	15,251	52
Thermal	8,188	5,174	-	13,362	46
Nuclear	-	-	440	440	2
	23,439	5,174	440	29,053	100

2.2.3 Changes in the usage of various fuels for thermal power plants

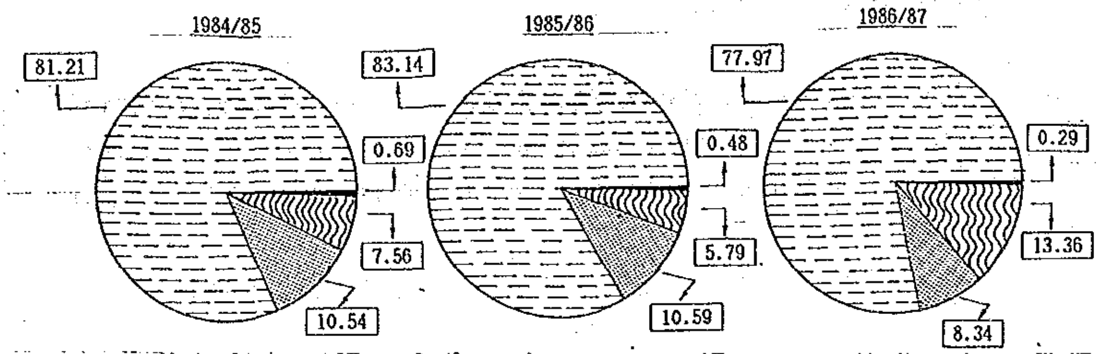
Changes in the ratio of generated electrical energy according to the categories of fuels for thermal power plants of WAPDA and KESC is presented in Fig. 2.2-4.

In the case of KESC, the ratio of generated electric energy from gas decreased from 81.21% to 45.05%, while that from heavy oil increased from 14.49% to 54.97% over a period of six years from fiscal 1980/81 through fiscal 1985/86.

Also in the case of WAPDA, the ratio of generated electric energy from gas decreased from 81 percent to 78 percent over a period of three years from fiscal 1984/85 through to fiscal

Fig. 2.2-4 FUEL MIX IN POWER GENERATION (TREND)

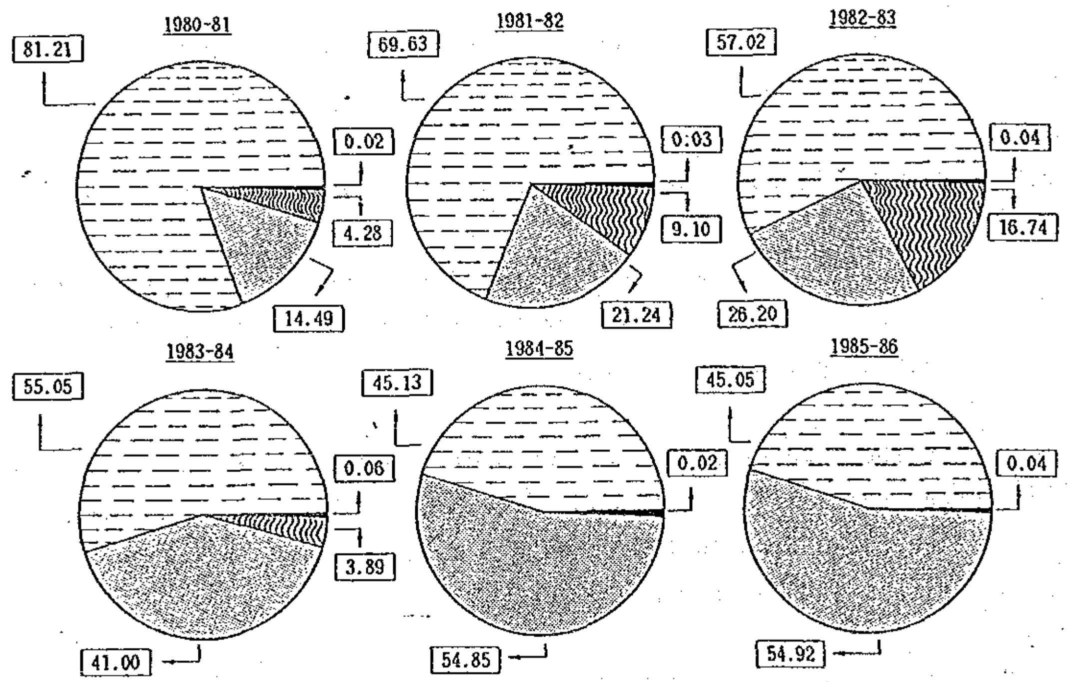
WAPDA



GAS
FURNACE OIL
HSD
COAL

Source:
WAPDA, ANNUAL REPORT, 1984/85~1986/87

KESC



GAS
FURNACE OIL
HSDO
LDO

Source:
KESC, POWER SYSTEM STATISTICS
FIRST ISSURE

1986/87.

It has become increasingly difficult to acquire additional supplies of gas for thermal power plants due to the short supply of natural gas in Pakistan. As a result, some existing thermal power plants have partly been converted from gas-firing to oil-firing. This indicates greater dependence on oil for thermal power plants.

At present, natural gas is allocated preferentially for civil and industrial uses, and construction of further gas-fired thermal power plants is not being approved by the government until new gas fields are developed and further natural gas production is realized.

Electric energy generated from coal-fired power plants is as small as 0.3 percent of the total generated electric energy of WAPDA, as coal is fired only at the Qutta Thermal Power Plant (15 MW).

Although coal resources available in Pakistan are estimated to be about 508 million tons, and the electric power sector is a potential market for coal, the majority of coal currently produced is consumed for brick production.

2.2.4 Installed Capacity of Power Plants

The installed capacity of power plants as of 1988 in Pakistan is about 6,600 MW. As much as 54 percent of the capacity is accounted for by thermal power plants.

The breakdown of the capacity is indicated in Table 2.2-2.

Table 2.2-2 Installed capacity of power plants in Pakistan

(Unit: MW)

	WAPDA	KESC	KANUPP	Total	Ratio (%)
Hydro-power	2,897	-	-	2,899	44
Thermal	2,480	1,138	-	3,618	54
Nuclear	-	-	137.5	137.5	2
Total	5,377	1,138	137.5	6,654.5	100

(1) Hydro-electric power plants

Hydro-electric power plants are concentrated mainly along the Indus River in the northern part of the country.

Large capacity hydro-electric power plants are located at the Tarbela and Mangla Dams.

At the Tarbela Hydro-Power Station, 175 MW x 10 units are installed. Total installed capacity is 1,750 MW. Eight 100 MW units are installed at the Mangla Hydro-electric Power Station, for a total installed capacity of 800 MW.

When the installed capacity of 240 MW at Warsack as well as other small hydro-power plants is combined, the total installed capacity of hydro-electric power plants is about 2,900 MW as of 1988. (Refer to Table 2.2-2 Existing hydro-electric power plants).

According to the extension plan of WAPDA, 432 MW x 4 units and 100 MW x 2 units are scheduled to be completed respectively at the Tarbela and Mangla Hydro-electric Power Stations by 1991.

(2) Thermal power plants

As of 1988 in Pakistan, the installed capacity of thermal power plants is 3,590 MW, out of which 2,482 MW units are owned by WAPDA and 1,108 MW units by KESC.

Regarding the configuration, the thermal power plants are comprised of steam power plants, gas turbine power plants, and diesel power plants.

A detailed configuration of thermal power plants is indicated in Table 2.2-3.

Table 2.2-3 Configuration of thermal power plants

(Unit: MW)

	WAPDA	KESC	Total
Steam power plants	1,169	883	2,052
Gas turbine power plants	1,183	225	1,508
Diesel power plants	30		30
Total	2,482	1,108	3,590

(Refer to Table 2.2-5 Existing thermal power plants (1/2) and (2/2)

According to the thermal power plant construction plants of WAPDA and KESC, thermal power plants with a combined total output of 4,000 - 5,000 MW are scheduled to be completed by 1993.

(3) Nuclear power plant

The first generation of nuclear power in Pakistan began when the KANUPP Nuclear Power Plant (137.5 MW) was commissioned in the outskirt of Karachi in 1971.

This power plant has been operating for more than fifteen years and has generated over 4.5 billion kWh. Due to the favorable experience and the reliable operation and maintenance of the KANUPP Nuclear Power Plant, the Pakistan Atomic Energy Commission (PAEC) is planning to construct a nuclear power plant comprised of three or four units (unit output: 900 MW) by the year 2000 (Refer to Table 2.2-6 Existing nuclear power plants).

2.2.5 Transmission and distribution facilities

All power transmission systems in Pakistan are divided into two major systems operated by WAPDA and KESC.

The planned power system will be used to supply electric power in the rainy season from both the Tarbela and Mangura Hydro-power Stations in the north to the load center, and from both the Jamshoro and Guddu Thermal Power Stations in the South to the load center in the dry season.

500 kV transmission lines were connected between Tarbela and Jamshoro, passing through Multan and Guddu in 1985.

At present, WAPDA and KESC are making efforts to reduce power losses by boosting the primary transmission voltage and improving the efficiency and control of the secondary system.

Consequently, the transmission and distribution loss was lowered to 23% in 1988. Moreover, in the future, KESC intends to lower this figure to 16% ultimately.

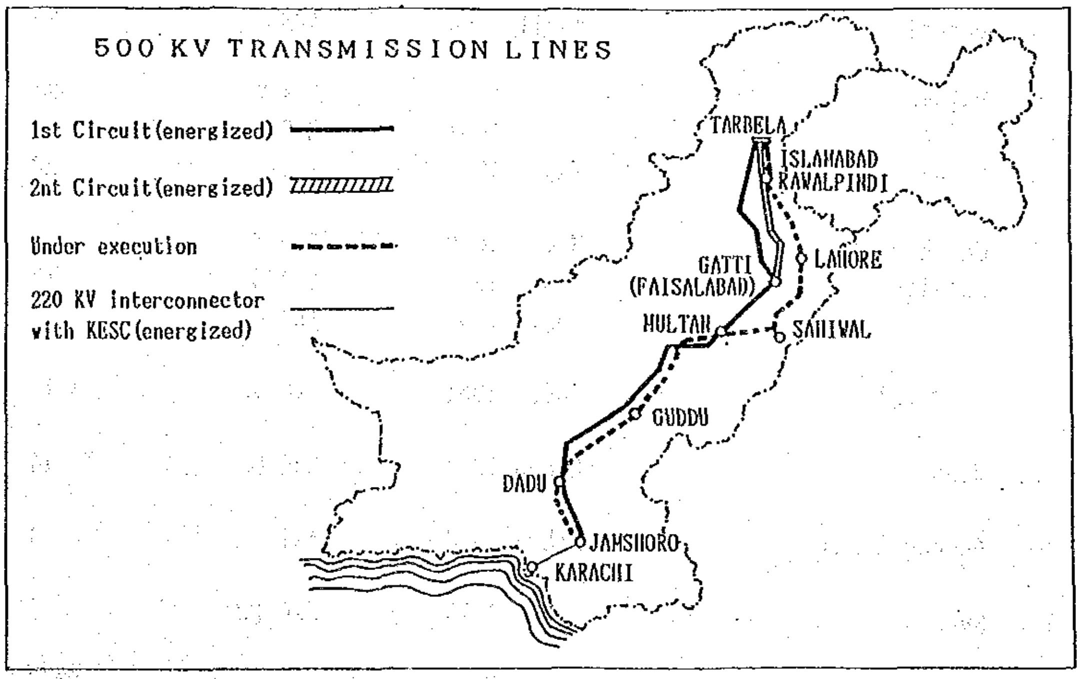


Table 2.2-4 INSTALLED CAPACITY OF WAPDA

A. HYDEL

Sr. No.	Name of Power Station	Date of Commiss-ioning	No. and Capacity of Units	Total Installed Capacity
1.	Tarbela	May 1977	2x175	
		Jure 1977	1x175	
		July 1977	1x175	
		Aug. 1982	2x175	1750
		Oct. 1982	2x175	
		Dec. 1982	1x175	
		Feb. 1985	1x175	
		May 1985	1x175	
2.	Mangla	July 1967	2x100	
		March 1968	1x100	
		June 1969	1x100	800
		Dec. 1973	1x100	
		March 1974	1x100	
		June 1981	2x100	
3.	Warsak	May 1960	2x40	
		June 1960	1x40	240
		July 1960	1x40	
		March 1981	2x40	
4.	Dargai	April 1954	4x5	20
5.	Malakand	1938	3x3.2	20
		1951	2x5	
6.	Rasul	May 1951	2x11	22
7.	Chichoki Mallian	May 1959	1x4.4	
		June 1959	1x4.4	13
		Aug. 1959	1x4.4	
8.	Shadiwal	June 1961	2x6.75	13
9.	Nandipur	March 1963	3x4.6	14
10.	Kurram Garhi	Feb. 1958	4x1	4
11.	Renala	1925	5x0.22	1
		Total Hydel:		2897

Table 2.2-5 (1/2) INSTALLED CAPACITY OF WAPDA

B. THERMAL (In MW)

Sr. No.	Name of Power Station	Date of Commissioning	No. and Capacity of Units	Total Installed Capacity
1.	Multan Steem	1960	2x65	260
		1963	2x65	
2.	Faisalabad Steam	1967	1x66	132
		1967	1x66	
3.	Faisalabad Gas Turbines	1975	2x25	
		1975	2x25	
		1975	1x25	200
		1975	2x25	
		1975	1x25	
4.	Shahdara Gas Turbines	1966	2x13.25	85
		1969	4x14.75	
5.	Guddu Steam	1974	1x110	640
		1974	1x110	
		1980	1x210	
		1986	1x210	
6.	Combustion Turbines at Guddu	1985	1x100	
		1986	1x100	400
		1986	1x100	
		1986	1x100	
7.	Sukkur Steam	1965	2x12.5	
		1967	2x12.5	50
8.	Hyderabad Steam (Gas Turbine Auxiliary)	1960	2x7.5	
			1x5.7	
		1965	1x8	43
			1x15	
9.	Kotri Gas Turbines	1970	1x15	130
		1970	1x15	
		1978	2x25	
		1981	2x25	

B. THERMAL (In MW)

Sr. No.	Name of Power Station	Date of Commissioning	No. and Capacity of Units	Total Installed Capacity
10.	Quetta	1964	2x7.5 Steam	15
		1972	1x5.7 Gas	
		1973	1x12.25 Gas	68※
		1975	1x25 Gas	
		1984	1x35 Gas	
11.	Kot Addu	1986	1×100	
		1986	1×100	400
		1986	1×100	
		1986	1×100	
12.	REPCO(TAKENOVER)	1981	1x1.5 Steam	9
			1x2.0	
			1x2.28	
			1x3.30	
13.	MESCO(TAKENOVER)	1981	2x10 Steam	20
14.	OTHERS		Diesel	30
		Sub-Total Thermal		2482MW

※ Derated Capacity

Table 2.2-5 (2/2) INSTALLED CAPACITY OF KESC

Power plant

S. No.	Power Station	Year of Commissioning	Installed Capacity (MW)
1.	Dual Fuel	1960	7×1.25=8.75
		1961	4×1.25=5.00
		1964	1×1.25=1.25
2.	West Wharf Steam	1956	(2×15=30) Retired in June 1987.
		1962	2×33=66
3.	Korangi Thermal	1965	2×66=132
		1970	1×125=125
		1977	1×125=125
4.	Korangi Gas Turbine	1978	4×25=100
5.	SITE Gas Turbine	1979	3×25=75
		1980	2×25=50
6.	Bin Qasim	1983	1×210=210
		1984	1×210=210
		Total	1,138 MW (1,108 MW)

After retiring the West Wharf 2×15MW in June 1987, the total installed capacity was reduced to 1,108MW.

Table 2.2-6 NUCLEAR POWER PLANT

KANUP	1972	137MW	PAEC

2.2.6 Organization of electric power supply operation in Pakistan

(1) Organization of WAPDA (Water and Power Development Authority)

Establishment: After establishment based on federal regulation, the electric power authorities in the respective districts and states were merged into WAPDA. Subsequent to merging the Rawalpindi Electric Power Co. (REPCO) and the Multan Electric Power System Co. (MESCO) in 1982, WAPDA entered into business collaboration with KESC in 1984.

Business lines:

- o Power generation, transmission and distribution, construction, maintenance and operation of power stations, substations and other electric power facilities, supply of electric power and collection of power charges
- o Utilization of water resources for irrigation, water supply and sewege, recreation and other purposes
- o Flood control
- o Prevention of swampy areas and reclamation of salt-contaminated land

Organization: Respective electric power and water utilization departments, project planning and office works are managed by four members (directors) under the supervision of the President.

(1) Power Wing

Under the Power Wing Director, eight general managers undertake responsibility for thermal and hydro-electric power stations, transmission and substations, distribution, planning and design, overall control and management. The respective general managers supervise all chief engineers.

(2) Water Wing

Under the Water Wing Director, this wing has the same organization as the Power Wing. Work undertaken comprises dam and irrigation planning and so forth.

(3) Project Planning & Review Organization

This organization is in charge of planning and review of projects.

(4) Finance & Administration Wing

This wing undertakes the responsibility for financing and administration of the entire WAPDA organization.

ORGANISATION

(as on 30th June, 1987)

Managing Director (Power)

G.M. (Co-ordination)
G.M. (Distribution)
G.M. (Finance) Power
G.M. (Hydel)
G.M. (Inventory Control)
G.M. (Thermal)
G.M. (Transmission and Grid Stations)

Member (Finance)

Chief Auditor
C.E. (Central Contracts Cell)
D.G. (Public Relations)
D.G. (Computer Centre)
Principal, Administrative Staff College, Tarbela
Manager (Finance) Co-ordination

AUTHORITY

CHAIRMAN
Member (Power)
Member (Water)
Member (Finance)

Secretary

Managing Director (Water)

G.M. (Central)
G.M. (North)
G.M. (South)
G.M. (Dams and Co-ordination)
G.M. (Kalabagh Dam)
G.M. (Planning)
G.M. (Tarbela)
Manager (Finance) Water

Administration

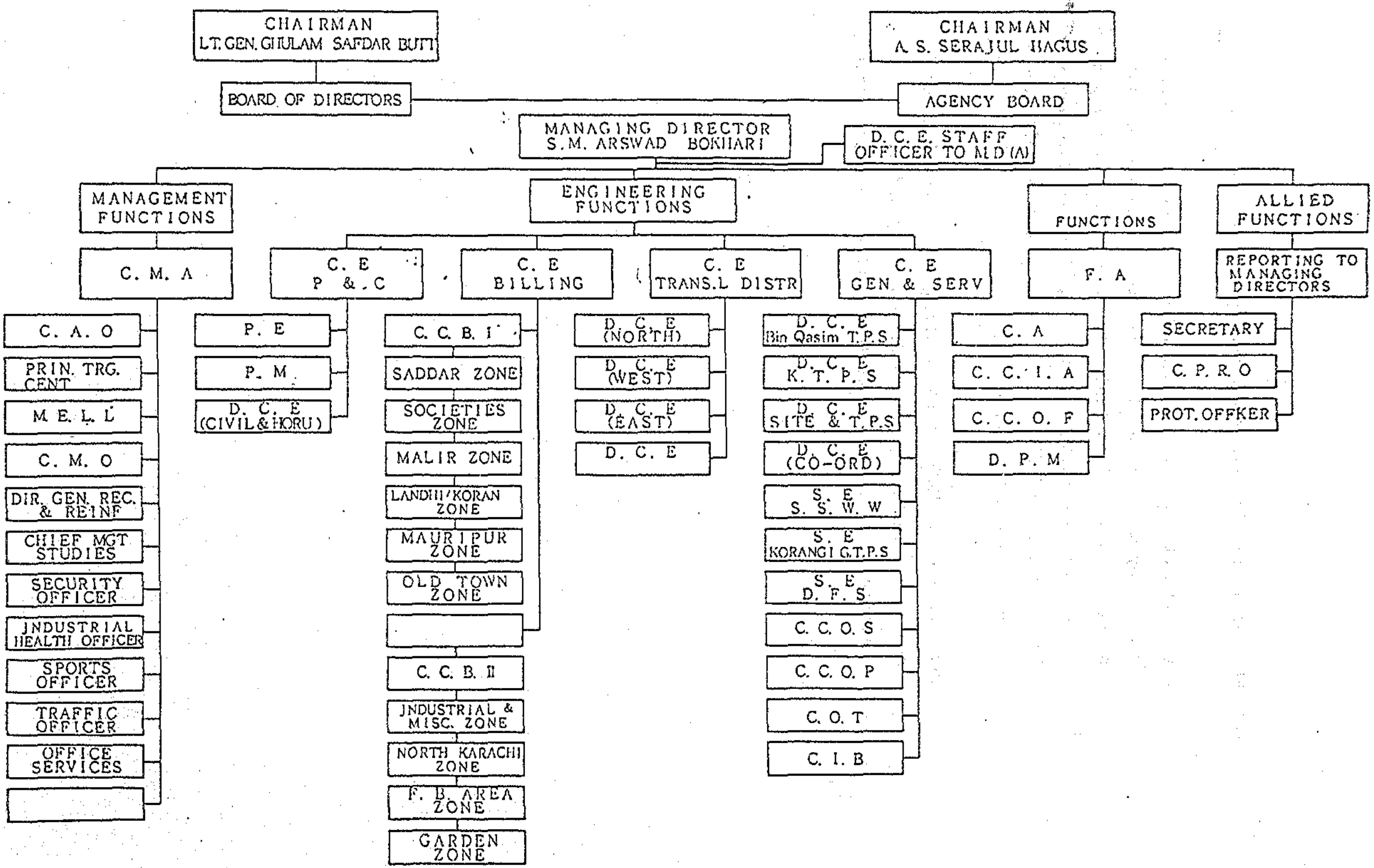
G.M. (Administration)
D.G. (Services and General Administration)
D.G. (Medical Services)
D.G. (Organisation and Methods)

(2) KESC (Karachi Electric Power Supply Corporation Ltd.)

Establishment: After establishment as a private electric power company in 1913, KESC operated as an independent private company since 1951. However, KESC was changed to a semi-public corporation in 1951, when the Government of Pakistan acquired 73% of its shares. Its organization is as shown in the following chart:

Business lines: KESC is undertaking the responsibility for supply of electric power to Karachi City and its surrounding area as well as to a part of Baltistan State.

ORGANISATION CHART



(3) PAEC (Pakistan Atomic Energy Commission)

Establishment: PAEC was established based on the Regulation for Establishment of the Pakistan Atomic Energy Commission in 1971.

Organization: Refer to the organization chart below.

Functions: Promotion of peaceful utilization of atomic power in the agricultural, medical and industrial fields, execution of nuclear power plants, various development projects and other activities, including all necessary research and development activities.

Meanwhile, a council has been established to support PAEC. This council is comprised of the PAEC Chairman, two directors, two general managers of affiliated research institutes, two scientists appointed by the university council, and five scientists appointed respectively by the Ministry of Agriculture, Ministry of Defence, Ministry of Insurance, Ministry of Natural Resources and Ministry of Chemical Engineering Research.

(Organization Chart of PAEC)

PAEC Chairman

- Standing Member in charge of finance
- Standing Member in charge of administration
- Standing Member in charge of engineering
- Part-time Members (2 - 3 scientists)
- Part-time Member (Chief science advisor to the President)
- Research and Development Institutions
  - Atomic Research Institute (PINSTECH)
    - Atomic Research Institute for Agricultural Biology (NIAB)
    - Atomic Power Energy Agricultural Research Center
    - Atomic Power Energy Mineral Center
    - Atomic Power Energy Medical Center
    - Radiation Treatment and Radiotherapy Research Institute
  - Kanupp Nuclear Power Station

PAKISTAN

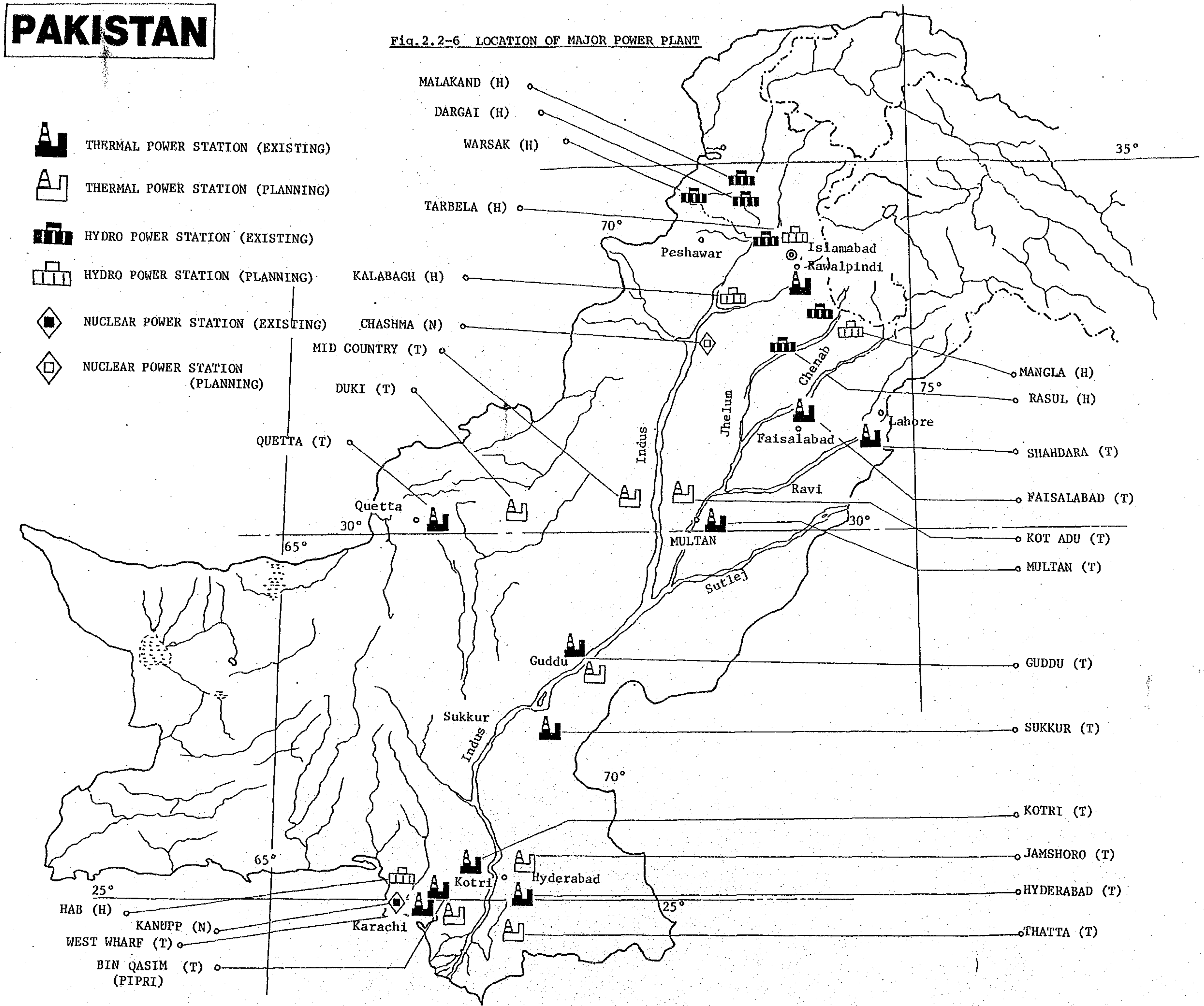


Fig.2.2-6 LOCATION OF MAJOR POWER PLANT

Chapter 3. REVIEW OF ELECTRIC DEMAND AND SUPPLY

3.1 Present Situation of Power Demand and Supply

3.1.1 General situation

(Note: period is fiscal year)

As of June 1987, KESC had a total installed generating capacity of 1,108 MW, comprising some 883 MW of gas/oil fired steam plants and 225 MW of gas turbine plants suppling power to about 830,000 consumers in its licensed area in greater Karachi.

The KESC power system is interconnected with WAPDA through 220 kV and 132 kV transmission lines, exchanging power between KESC and WAPDA. The maximum system demand and total energy sales in the KESC licensed area (excluding sales to WAPDA) in 1986 were 945 MW and 3,963 GWh, respectively.

Before commissioning of the Bin Qasin Steam Power Plant (B.Q.P.P.) in July 1983 for Unit 1 (210 MW) and May 1984 for Unit 2 (210 MW), which is located in southeastern part of Karachi and is the largest power plant in KESC, KESC had been faced with a very tight supply situation forcing the adoption of energy saving measures and load shedding during times of peak load.

At present, there is no load shedding and/or special energy saving measures in the KESC system. However, the supply and demand situation has become increasingly tight year by year. In the next few years, it is expected to enter a critical stage as experienced prior to 1983 and until the Bin Qasim P.P. Units 3 and 4, now under construction, are put into operation.

Meanwhile, WAPDA is now in a very tight situation regarding the demand and supply balance, particularly in the dry season, and there is no assistance available even through power import from WAPDA would be technically possible through a 220 kV interconnecting transmission line. This situation is seen to continue until some time after 1990.

KESC has been obtaining some power from the Karachi Nuclear Power Plant (KANUPP) and the Pakistan Steel Mill Corporation (PASMIC) located in its licenced area. However, KANUPP is scheduled to be retired in 1992, and the power from PASMIC can be expected only when it has a surplus amount.

Taking these circumstances into consideration, KESC, by its own efforts, must promote power source expansion to meet demand requirements until WAPDA is capable of supplying enough power to KESC.

3.1.2 Review of past electricity situation

(1) Generation and sales

From 1979 to 1986, the total electricity sales without WAPDA (excluding those exported to WAPDA) increased from 2,175 GWh to 3,963 GWh, an average annual increase of 8.9%.

The average annual increase in maximum demand and gross energy generation (KESC's own plus imports but without WAPDA) were 8.9% and 9.5%, respectively.

	1979	1986	Average annual increase
System peak demand (MW)	519.9	945.0	8.9%
Gross energy generation (GWh)	2,749	5,173	9.5%
Energy sales (GWh)	2,175	3,963	8.9%

. The above figures all exclude those exported to WAPDA.

. Details refer to Tables 3.1, 3.2 and 3.3.

On a year to year basis, there is no constant growth rate, particularly before commissioning of the Bin Quasim P.P. Units 1 and 2, as shown in Tables 3.1, 3.2 and 3.3.

The reason is that power development of KESC had been lagging, unable to catch up with the demand. When a new generator set was commissioned, the suppressed load was released, leading to a higher growth rate than the average.

The tables clearly show that after commissioning of the Bin Qasim P.P. in 1983, the electrical situation of KESC greatly improved.

Historical data regarding power sources, and the supply and demand balance are shown in Table 3.4 and Fig. 3.1, respectively.

(2) Electricity consumption of consumer categories

The pattern of consumption by consumer catagories is as shown in Table 3.5.

As noted in the table, consumption of residential and industrial consumers is almost equal, occupying more than 70% of the total consumption. This is followed by commercial consumption, about 15 - 20%.

The bulk supply amount, which consists of WAPDA, KANUPP, PASMIC, governmental and construction use, shows large differences by year in accordance with changes in supply to WAPDA.

In 1984 and 1985, the bulk supply occupied a large amount, 17.7% and 14.1% to the total amount respectively, indicating that KESC had sufficient surplus due to commissioning of the Bin Qasim P.P. Units 1 and 2 in 1983.

The similar composition of electricity consumption by consumer categories is seen to continue for some time into the future, except for WAPDA.

(3) System loss

As noted in Table 3.6, the loss in 1980 shows the highest value of 23.0% for line loss and 27.2% for total loss. After 1982, the loss has decreased steadily to 18.5% for line loss and 23.4% for total loss in 1986. The loss in the future can be expected to decrease gradually in parallel with the improvement in the KESC system, now being promoted under the KESC system development plan.

(4) Load factor

The load factor in the respective fiscal years in the past is as indicated in Table 3.7.

The load factor in the table was calculated from the maximum load (MW) and generated electrical energy (GWh) excluding those supplied to consumers from WAPDA. In other words, the load factor herein refer to that within the supply area of KESC. The load factor in 1979 through 1986 was within a range of 60 - 64%. According to the daily load curves in 1986.

According to the daily load curves in 1986 shown in Figs. 3.2-1 and 3.2-2, the yearly maximum peak demand appears in the summer evening, and the gap between the day time and night time demand is small and extends roughly from 700 MW to 945 MW. Although the peak demand also appears in the winter evening, the demand is roughly 880 MW. Thereby, it has become extremely difficult under the present load conditions to not only perform scheduled shutdown of large scale thermal power sources (200 MW class) but also secure reserve capacity of thermal power sources.

When the structure of power demand is viewed from the change in the load factor, the change in the past load factor was limited to a narrow range. Even in the light of the fact that the configuration of category wise load had roughly been constant, the load factor is predicted to undergo a similar transition in the future as well.

Table 3.1 Histrical Data of Peak Demand of KESC System (Without WAPDA)

(1) Peak Demand (MW)

Year	Peak Demand
1979	519.9
80	540.0
81	588.8
82	618.0
83	732.0
84	797.0
85	872.0
1986	945.0

(2) Average Annual Growth Rate of Peak Demand (%)

	1979	80	81	82	83	84	1985
1980	3.9						
81	6.4	8.0					
82	5.9	7.0	5.0				
83	8.9	10.7	11.5	18.5			
84	8.9	10.2	10.6	13.6	8.9		
85	9.0	10.1	10.3	12.2	9.1	9.4	
1986	8.9	9.8	10.0	11.2	8.9	8.9	8.4

Table 3.2 Historical Data of Generated Energy of KESC System (Without WAPDA)

(1) Generated Energy (GWh)

Fiscal year	Generation by KESC plants a	Imports b	Generated for export to WAPDA *c	Total generated energy for KESC system d = a+b−c
1979	2,764	2	17	2,749
80	2,764	184	3	2,945
81	2,788	442	35	3,195
82	3,001	487	10	3,478
83	3,556	474	44	3,986
84	4,528	450	696	4,282
85	4,582	619	489	4,712
1986	4,772	600	198	5,174

* (c): Calculated by mutiplying 1.03 to those exported to WAPDA (See Table 3.8)

(2) Average Annual Growth Rate of Generated Energy (%)

	1979	80	81	82	83	84	1985
1980	7.1						
81	7.8	8.5					
82	8.2	8.7	8.9				
83	9.7	10.6	11.7	14.6			
84	9.3	9.8	10.3	11.0	9.9		
85	9.4	9.9	10.2	10.7	8.7	10.0	
1986	9.5	9.8	10.1	10.4	9.1	9.9	9.8

Table 3.3 Historical Data of Sold Energy of KESC System (Without WAPDA)

(1) Sold Energy (GWh)

Year	*Total sales (GWh)	Exported to WAPDA (GWh)	Sales without WAPDA (GWh)
1979	2,191	16	2,175
80	2,147	3	2,144
81	2,500	34	2,466
82	2,596	9	2,587
83	3,032	43	2,989
84	3,872	675	3,197
85	4,064	475	3,589
1986	4,155	192	3,963

* Total sales include the free electricity to staff, but do not include those exported to WAPDA (See Table 3.8)

(2) Average Annual Growth Rate of Sold Energy (%)

	1979	80	81	82	83	84	1985
1980	-1.4						
81	6.5	15.0					
82	5.9	9.8	4.9				
83	8.3	11.7	9.8	15.6			
84	8.0	10.5	11.7	11.2	6.9		
85	8.7	10.9	10.5	11.5	9.6	12.3	
1986	8.9	10.8	10.0	11.3	9.9	11.3	10.4

Table 3.4 Historical Data of Installed and Actual Capacity of KESC Power Plants

Name of power plant	1979	80	81	82	83	84	85	1986
Dual Fuel	15/11	"	"	"	"	"	"	15/11
West Wharf	96/80	"	"	"	"	96/74	96/49	66/50
Korangi T.	382/300	"	382/320	382/296	382/340	382/357	382/382	382/376
Korangi G.T.	100/80	"	"	"	"	"	"	100/80
SITE G.T.	125/100	"	"	"	"	"	"	125/100
Bin Qasim	-	-	-	-	420/420	"	"	420/420
Total	718/571	"	718/591	718/567	1138/1031	1138/1042	1138/1042	1108/1037

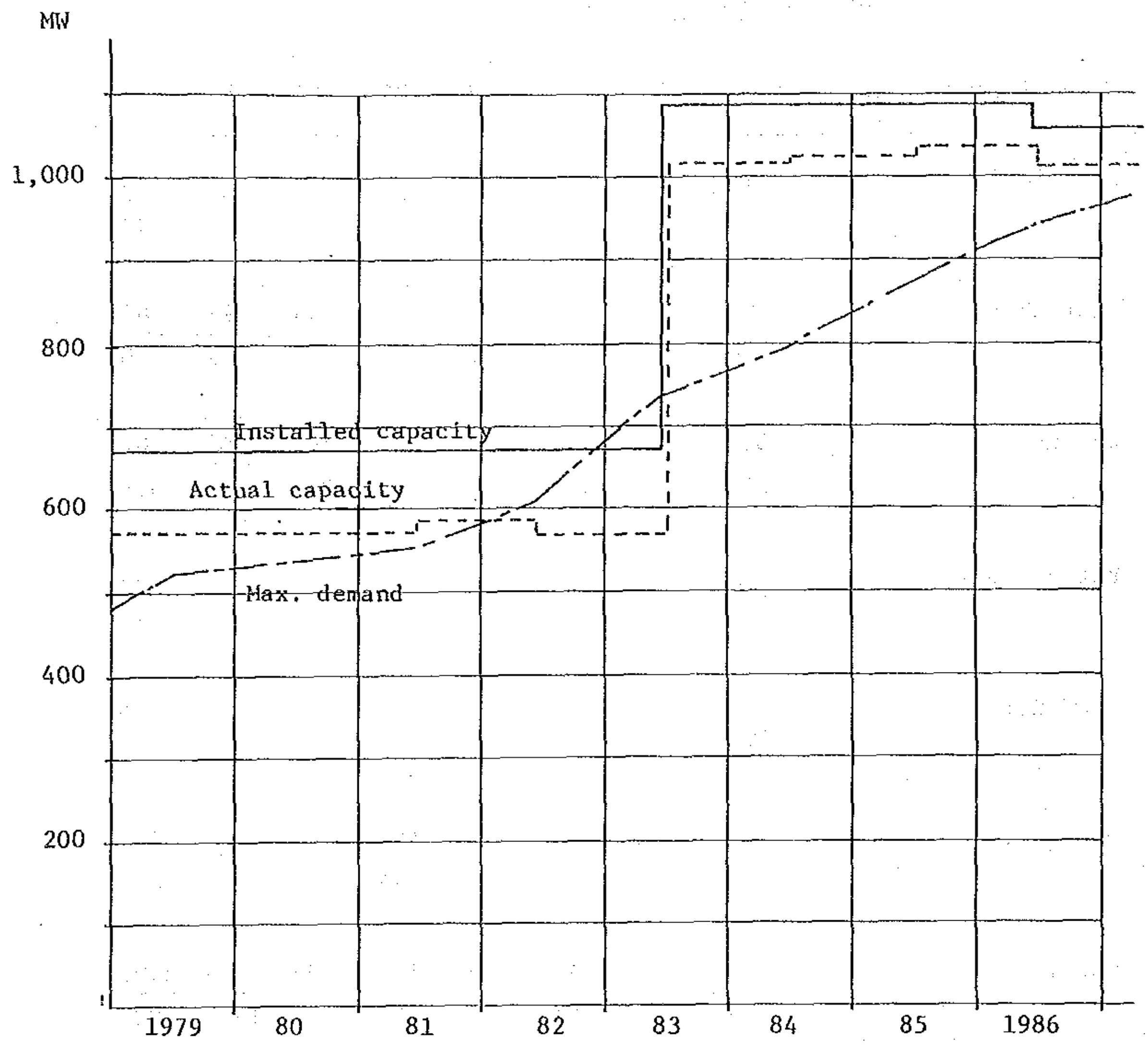
Notes: (1) The installed capacity of gas turbines is at ISO conditions.

(2) upper/lower

. Upper side indicates "installed capacity".

. Lower side indicates "actual capacity".

Fig. 3.1 KESC Power Supply Situation (1979 - 1986)



Notes: 1. In the installed/actual capacity, import from KANUPP (max. 83 MW in 1986) and PASMIC (max. 50 MW in 1986) is not included.

2. Maximum demand shows that of the KESC system but does not include export to WAPDA.

Table 3.5 Pattern of Consumption

(Percentage of total)

Year	Residential	Commercial	Industrial	Agriculture	Public Lighting	*Bulk Supply	Total
1979	34.11	20.60	41.47	0.51	1.33	1.98	100.00
1980	35.05	19.49	43.68	0.42	0.84	0.52	100.00
1981	35.45	18.51	41.93	0.40	1.13	2.58	100.00
1982	36.02	19.42	40.18	0.50	1.16	2.72	100.00
1983	36.35	18.54	39.47	0.43	0.93	4.28	100.00
1984	31.26	15.06	34.84	0.34	0.80	17.70	100.00
1985	33.66	16.11	34.68	0.49	0.99	14.07	100.00
1986	35.88	17.51	37.77	0.46	0.87	7.51	100.00

* Bulk supply covers the sales energy to WAPDA, KANUPP, PASMIC, governmental and construction use.

Table 3.6 Power Loss of KESC System

Year	Generated energy Gwh	Station use Gwh	Imported energy Gwh	*(1) Total sales Gwh	Exported to WAPDA Gwh	*(2) Line loss %	*(3) Total loss %
	a	b	c	d	e	f	g
1979	2,764	171	2	2,191	16	15.6	20.1
80	2,764	161	184	2,147	3	23.0	27.2
81	7,788	161	442	2,500	34	18.7	22.8
82	3,001	167	487	2,596	9	21.9	26.0
83	3,556	239	474	3,032	43	20.2	25.0
84	4,528	300	450	3,872	675	19.7	25.4
85	4,582	305	619	4,064	475	18.6	23.8
1986	4,772	314	600	4,155	192	18.5	23.4

* (1) : Total sales include free electricity to staff.
* (2) : System loss means the loss without station use and WAPDA.
* (3) : Total loss means the loss with station use but without WAPDA.

Line loss (f) and total loss (g) are determined according to the following formulas.

$$(f) = 1 - \frac{d - e}{a + c - b - e \times 1.03}$$

$$(g) = 1 - \frac{d - e}{a + c - e \times 1.03}$$

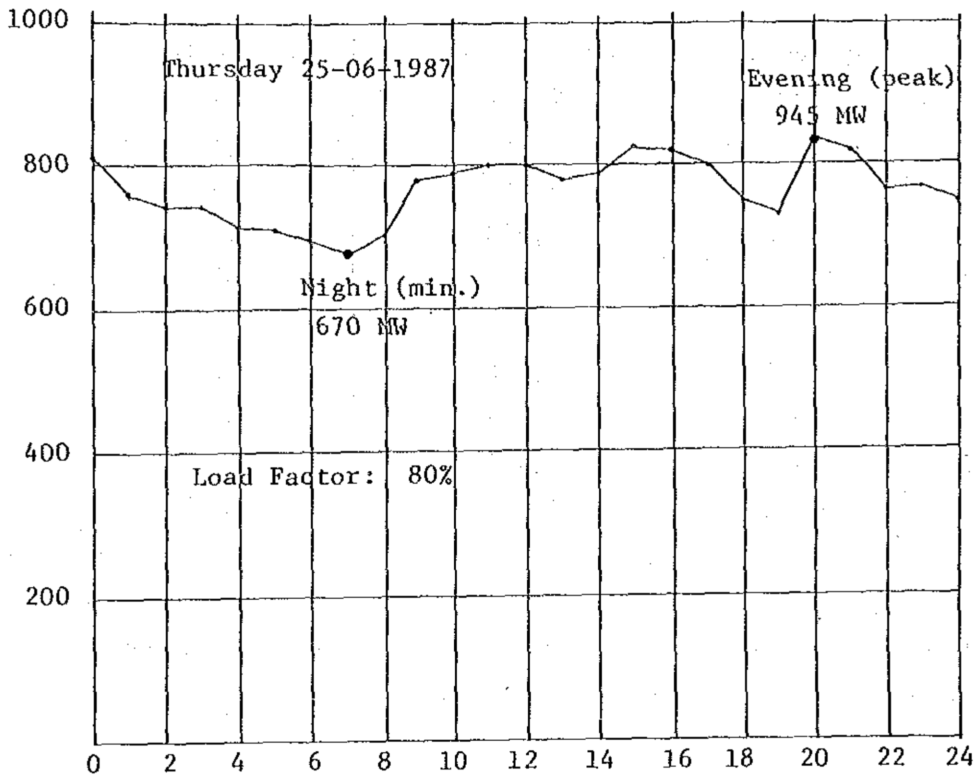
1.03 is the coefficient to convert the exported power to WAPDA to the generation power side, assuming a system loss of 3%.

Table 3.7 Historical Data of Load Factor (Without WAPDA)

Year	Peak demand (MW)	Power generation (GWh)	Load factor (%)
1979	519.9	2,749	60
80	540.0	2,945	62
81	588.8	3,195	62
82	618.0	3,478	64
83	732.0	3,986	62
84	797.0	4,282	61
85	872.0	4,712	63
1986	945.0	5,174	63

Peak demand and power generation do not include those exported to WAPDA. (Refer to Tables 3.1 and 3.2).

Fig. 3.2-1 Daily Load Curve of KESC System (Summer)



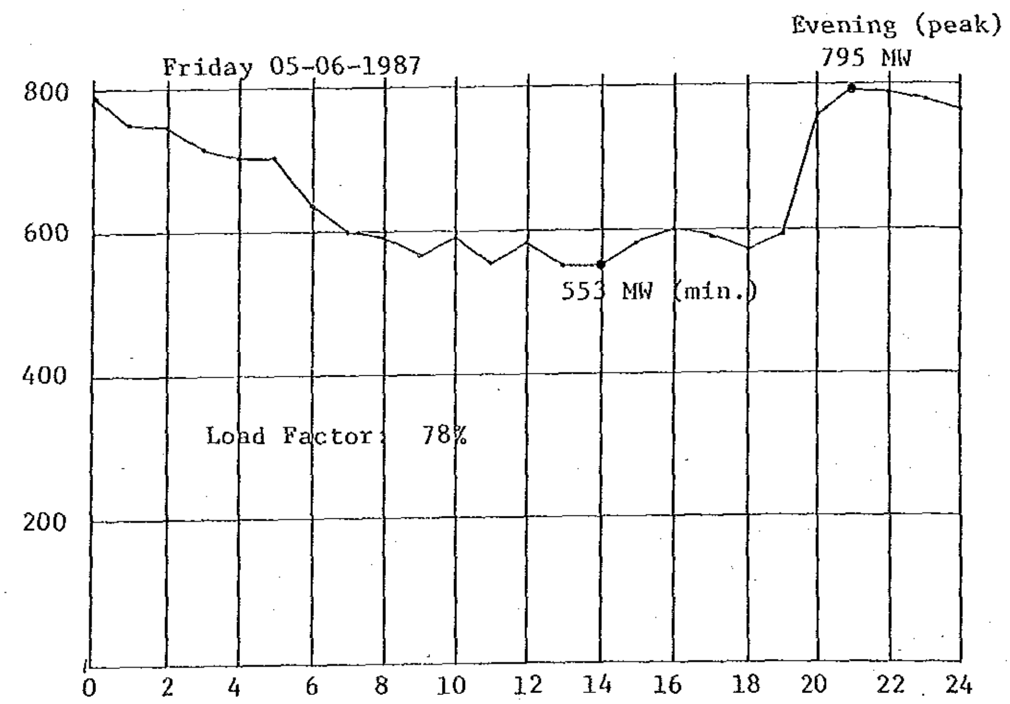
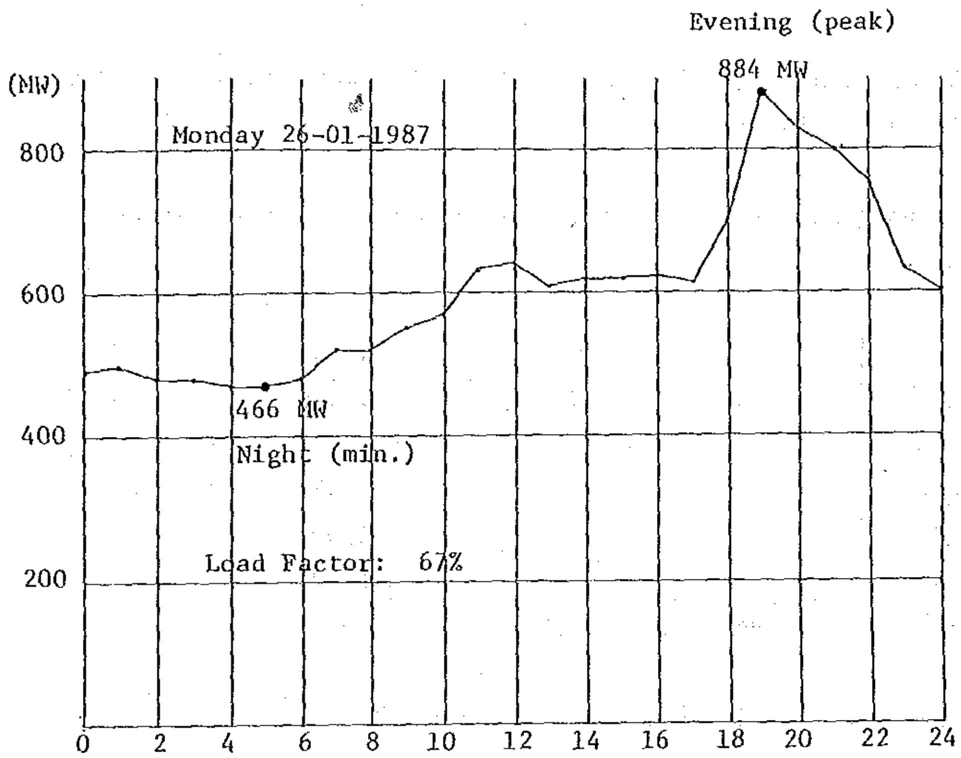
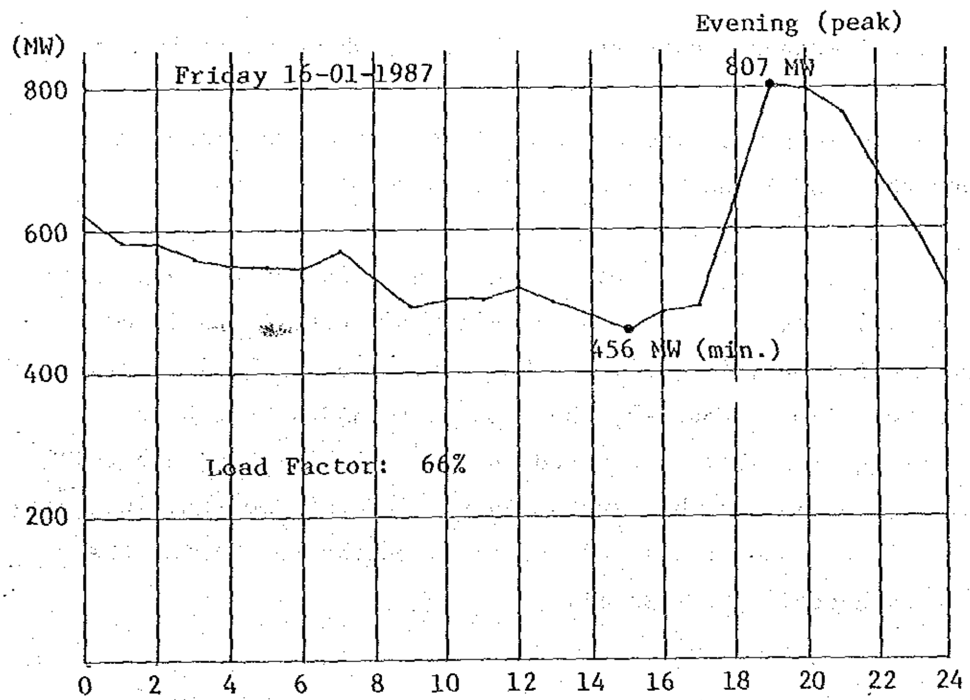


Fig. 3.2-2 Daily Load Curve of KESC System (Winter)





3.2 Power Exchange with Others

3.2.1 Outline of power exchange

KESC has been exchanging power with WAPDA, KANUPP and PASMIC as outlined previously.

The import and export of energy and power in 1986 are as shown below.

Agency	Export GWh	Import GWh	Max. MW Exp./Imp.
KANUPP	-	440	- /83
PASMIC	2	153	24/50
WAPDA	192	6	310/82
Total	194	599	-

Monthly exchange in 1986 is as shown in Fig. 3.3.

3.2.2 Exchange with WAPDA

Historical exchange data with WAPDA is as shown in Table 3.8.

As the table shows, imports from WAPDA were almost zero, which means that WAPDA had no extra power to supply to KESC.

Meanwhile, exports to WAPDA from KESC have increased remarkably since 1984. This is because the Bin Qasim P.P. Units 1 and 2 were commissioned in 1983, and KESC was able to obtain extra power for WAPDA. However, the exports to WAPDA have been decreasing gradually. As noted in Fig. 3.3, in 1986, about 90% was exported in December and January. In other months, including May, which is one of the most critical months for WAPDA, the power exchange is very small.

These facts indicate that the power exchange was carried out only on very few occasions when WAPDA/KESC had a surplus of power. A stable power exchange, therefore, can hardly be expected until after either one obtains sufficient power sources.

Considering the present tight situation of WAPDA on the demand and supply situation, it will be difficult for KESC in the near future to obtain a stable and sufficient power supply from WAPDA to maintain a favorable balance in the supply and demand situation of the KESC system.

The system interconnection, however, has a big advantage regarding stable and economical system operation due to frequency stability and economical power exchange between both systems.

3.2.3 Exchange with PASMIC

PASMIC has been running in synchronization with the KESC system with its 55 MW x 3 units. In 1986, supply to PASMIC from KESC was very small, about 2 GWh. However, KESC imported 153 GWh from PASMIC, with the maximum demand of export and import with PASMIC amounting to 24 MW and 50 MW, respectively. This indicates that PASMIC has surplus power to send to KESC after commissioning of Unit 3 (55 MW) in 1986.

Monthly imported energy in 1986 from PASMIC is as shown in Fig. 3.3. Historical data supplied by PASMIC is as shown in Table 3.9. PASMIC can be expected to supply some power to KESC in the future also, but this will depend on the mill plant operation and/or expansion program. Nevertheless, the supply amount is rather small in comparison with the total demand of KESC.

Considering these situations, imports from PASMIC were handled as an allowance in the study of future supply and demand in the KESC system.

3.2.4 Exchange with KANUPP

Energy supply in 1986 from KANUPP was 440 GWh, or about 8.5% of the total generation including imported energy for the KESC licensed area. Also, the maximum demand supplied to KESC from KANUPP was 83 MW.

As Fig. 3.3 shows, the monthly energy supply from KANUPP indicates rather flat, which means that KESC can expect almost the same amount of power from KANUPP by 1992 when KANUPP is scheduled to be retired.

Historical data supplied by KANUPP is as shown in Table 3.9.

Fig. 3.3 Monthly Export & Import Energy (GWh) in 1986

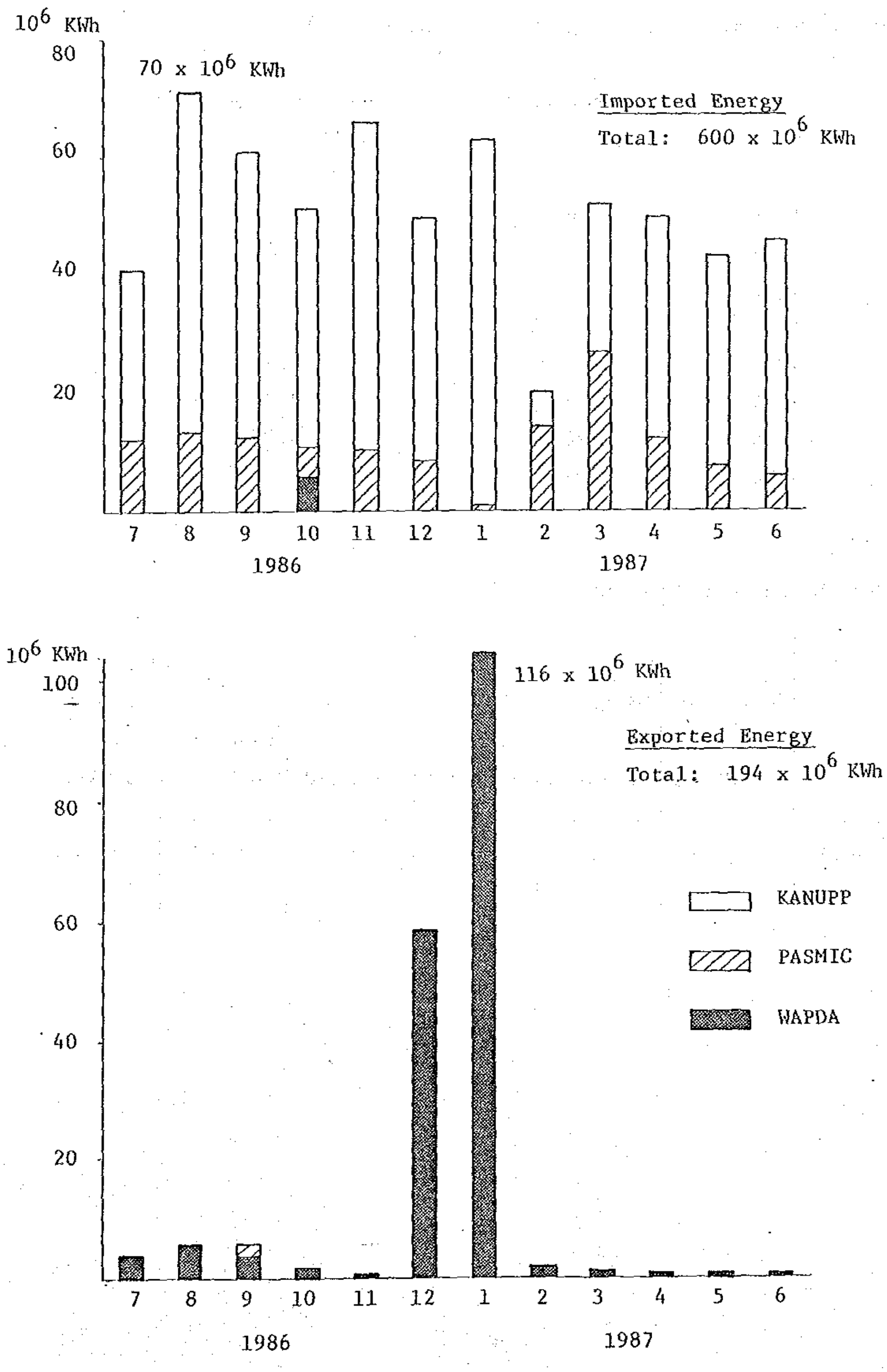


Table 3.8 Historical Data on Power Exchange with WAPDA

(1) Export and Import of Energy to/from WAPDA (GWh)

Year	Exported to WAPDA	Imported from WAPDA
1979	16.14	0.68
1980	3.25	16.27
1981	33.60	8.96
1982	9.33	7.87
1983	43.08	6.05
1984	675.48	0.97
1985	474.66	0.55
1986	192.27	5.71

(2) Peak Demand with/without WAPDA (MW)

	1984		1985		1986	
	With exports to WAPDA	Without exports to WAPDA	With exports to WAPDA	Without exports to WAPDA	With exports to WAPDA	Without exports to WAPDA
System peak demand	1,036	797	1,042	872	1,033	945

Table 3.9 Historical Data on Energy Supplied by KANUPP and PASMIC

Power sources	Capacity
Karachi Nuclear Power Plant (KANUPP)	* 125 MW
Pakistan Steel Mill Corporation (PASMIC)	165 MW

* Capability is assumed to be about 70 - 80 MW.

Supply of Energy (GWh) to KESC

Agencies	1983	1984	1985	1986
KANUPP	188	219	378	441
PASMIC	280	230	241	153

3.3 Electrical Facilities of KESC

Outlines of the electrical facilities of KESC, as of 30/6/1986, are as follows.

3.3.1 Power plant

The total installed capacity was 1,138 MW and comprised six power plants. Details are as shown in Table 3.10-1.

After retiring the West Wharf 'B' station (2 x 15 MW) in June 1987, the total installed capacity was reduced to 1,108 MW.

3.3.2 Transmission line

The total line length was 526 km and comprised 220 kV, 132 kV and 66 kV. Details are as shown in Table 3.10-2-i).

3.3.3 Grid station

The total transformer capacity was 2,605 MWA and comprised 31 grid stations. Details are as shown in Table 3.10-2-ii).

3.3.4 Distribution system

The line voltages of the distribution system are 11 kV for the medium voltage line and 400 V for the low voltage line. Details are as shown in Table 3.10-2-iii).

Table 3.10-1 Electrical Facilities of KESC as of 30/6/1986

Power plant

S. No.	Power Station	Year of Commissioning	Installed Capacity (MW)
1.	Dual Fuel	1960	7 x 1.25 = 8.75
		1961	4 x 1.25 = 5.00
		1964	1 x 1.25 = 1.25
2.	West Wharf Steam	1956	(2 x 15 = 30) Retired in June 1987.
		1962	2 x 33 = 66
3.	Korangi Thermal	1965	2 x 66 = 132
		1970	1 x 125 = 125
		1977	1 x 125 = 125
4.	Korangi Gas Turbine	1978	4 x 25 = 100
5.	SITE Gas Turbine	1979	3 x 25 = 75
		1980	2 x 25 = 50
6.	Bin Qasim	1983	1 x 210 = 210
		1984	1 x 210 = 210
		Total	1,138 MW (1,108 MW)

After retiring the West Wharf 2 x 15 MW in June 1987, the total installed capacity was reduced to 1,108 MW.

Table 3.10-2 Electrical Facilities of KESC as of 30/6/1986

i) Transmission line length (km)

Line Voltage	Karachi	Baluchistan (Vinder, Uthal and Bela)	Total
220 kV	68	-	68
132 kV	208	157	365
66 kV	93	-	93
TOTAL	369	157	526

ii) Grid station capacity (MVA)

S. No.	Grids	Nos.	220/132 kV	132/66 kV	132/11 kV	66/11 kV
A.	Karachi					
1.	220/132/11 kV	3	1,000	-	-	-
2.	132/66/11 kV	4	-	390	-	-
3.	132/11 kV	11	-	-	760	-
4.	66/11 kV	9	-	-	-	395
B.	Baluchistan					
1.	132/11 kV	4	-	-	60	-

Total number = 31

Total capacity = 2,605 MVA

iii) Distribution system

Description			
11 kV	Overhead	Km	769
11 kV	Underground	km	1,841
400 V	Overhead	km	6,036
400 V	Underground	km	361
11 kV	Distribution sub-stations	Number	2,956
11 kV	Distribution capacity	MVA	1,692,010
Street Lights		Number	109,410

3.4 Load Forecast

3.4.1 Basic conception of load forecast

With commissioning of the Bin Quasin P.P. in 1983 the electrical situation of KESC was improved, but the margin in supply and demand has been decreasing year by year. The actual demand in the near future will be limited to within the maximum generation capability, namely, existing facilities and completion of power expansion projects now underway. As mentioned previously, past data of supply and demand of the KESC system shows that, when the new generation facilities were commissioned, the demand increased sharply compensating for the suppressed demand, and the average annual growth rate in a long period reached a moderate value.

Such a tendency will continue further in the future until after the system has enough power capacity to meet the demand increase. It would be advantageous, therefore, to advance the load forecast for the power development plan based on a long range view using a hypothetical load projection which ignores, if any, restriction on the demand increase by year from the generating capability.

Concerning sales to WAPDA, KESC will occasionally send power as before, but only when it has a surplus. The amount to be sent is, as yet, unstable and very difficult to forecast, and, therefore, sales to WAPDA are not considered in the forecast.

3.4.2 Forecast of sales energy

According to past records of sales energy (GWh), the average annual growth rate was 8.9% from 1979 to 1986, and 10.8% from 1980 to 1986. After the Bin Qasim P.P. Units 1 and 2 were commissioned in 1983, the average annual growth rate from 1984 to 1986, during which time no load restriction was imposed, was

11.3% (Refer to Table 3.3).

Considering that the electrical situation in KESC's licensed area will not change much in the 1990's as compared with that in the 1980's, it would seem appropriate that the average annual growth rate of sales energy be in the range of 11% at the highest and 9% at the lowest.

3.4.3 Forecast of peak demand

As noted in item 3.1.2 (3), the system loss can be expected to decrease gradually. In projecting the peak demand forecast, it was assumed that for the next ten years the total loss will decrease at an annual rate of 0.5%, namely, from 23.4% in 1986 (actual) to 18.4% in 1996. Meanwhile, as described in item 3.1.2 (4), the load factor should maintain the same level as that of 1986, namely, 63% (actual).

Based on these assumptions and the growth rate adopted in item 3.4.2 for sales energy forecast, the peak demand in the future is predicted to be in the range of an annual growth rate of 10.5% (11% - 0.5%) at the highest and 8.5% (9% - 0.5%) at the lowest.

3.4.4 Review of KESC forecast

The forecast for sales energy and peak demand by KESC is as shown in Table 3.11, which was worked out based on M/S Electrowatt & Fitchner Consulting Engineer's Feasibility Study Report on KESC Generation and Transmission System, submitted in November, 1982 and its revision by KESC.

The outline is as shown below.

	Sales		Peak demand	
	GWh	Annual growth rate (%)	MW	Annual growth rate (%)
1985 (Actual)	3,589		872	
		10.5		10.4
1990	5,910		1,429	
		8.7		8.5
1994	8,244		1,981	
				7.3
1997	-		2,449	
Total	(1985 - 1994)	9.7	(1985 - 1997)	9.0

The comparison between the forecasted range in items 3.4.2 and 3.4.3 and KESC's forecast is as shown in Fig. 3.4 for sales energy and in Fig. 3.5 for peak demand.

As for sales energy, KESC's forecast is in good correspondence to the forecasted range of the JICA Study Team.

Meanwhile, the peak demand by KESC indicates a somewhat pessimistic outlook in the latter part but is still in the forecasted range by the JICA Study Team.

When considering the present tight situation in power balance and also the lagging trend of the construction schedule of power plant projects, it can be said that KESC's forecast will be realistic and adequate.

Table 3.11 KESC's Forecast for Sales Energy and Peak Demand

Year	Sales (GWh)	Peak demand (MW)	
1985	(3,589)	(872)	(Actual)
86	4,074	991	
87	4,489	1,086	
88	4,920	1,190	
89	5,392	1,304	
1990	5,910	1,429	
91	6,477	1,558	
92	7,099	1,698	
93	7,667	1,834	
94	8,244	1,981	
95		2,139	
96		2,289	
1997		2,449	

Fig. 3.4 Sales Energy Forecast (Gwh)

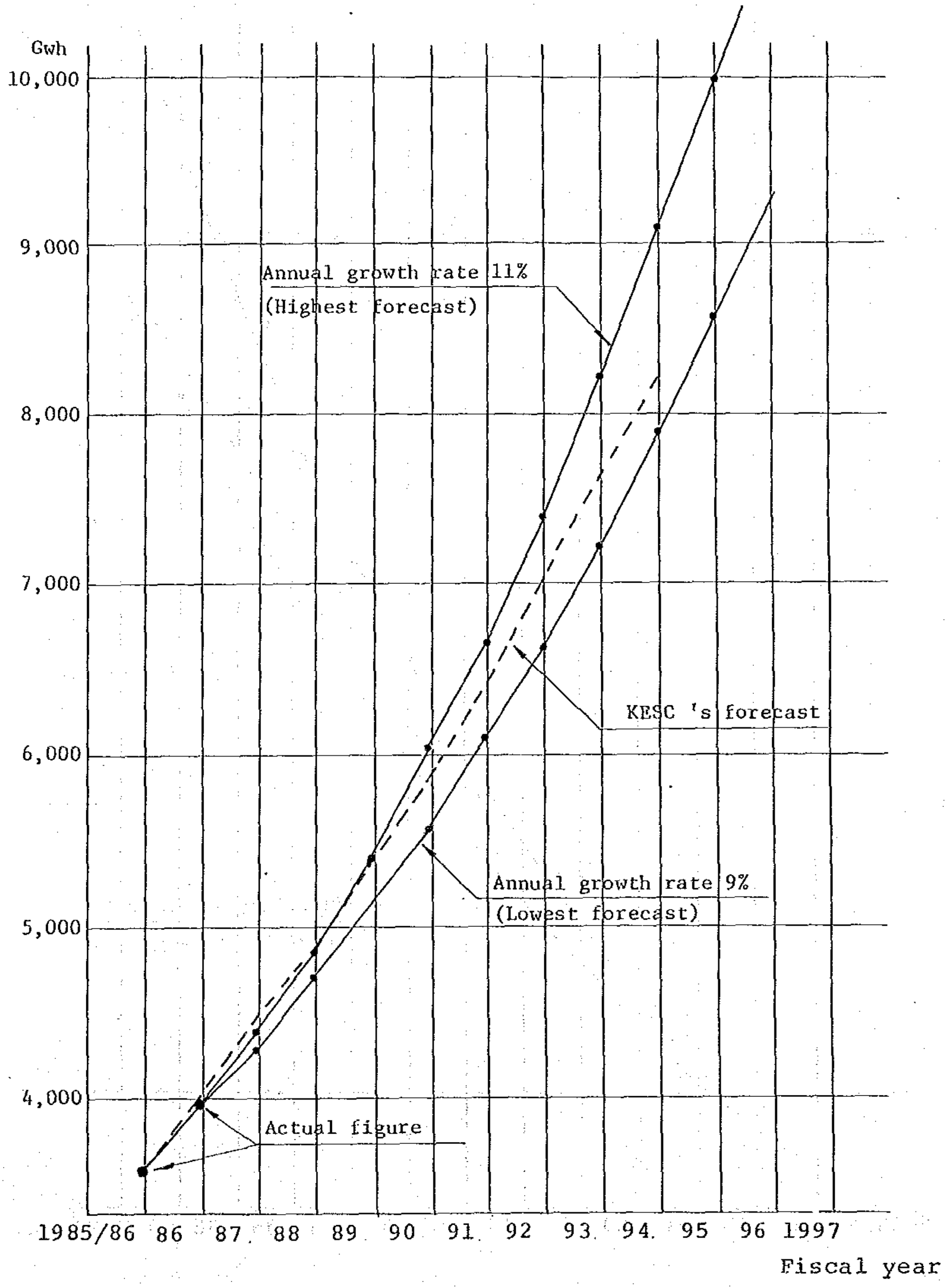
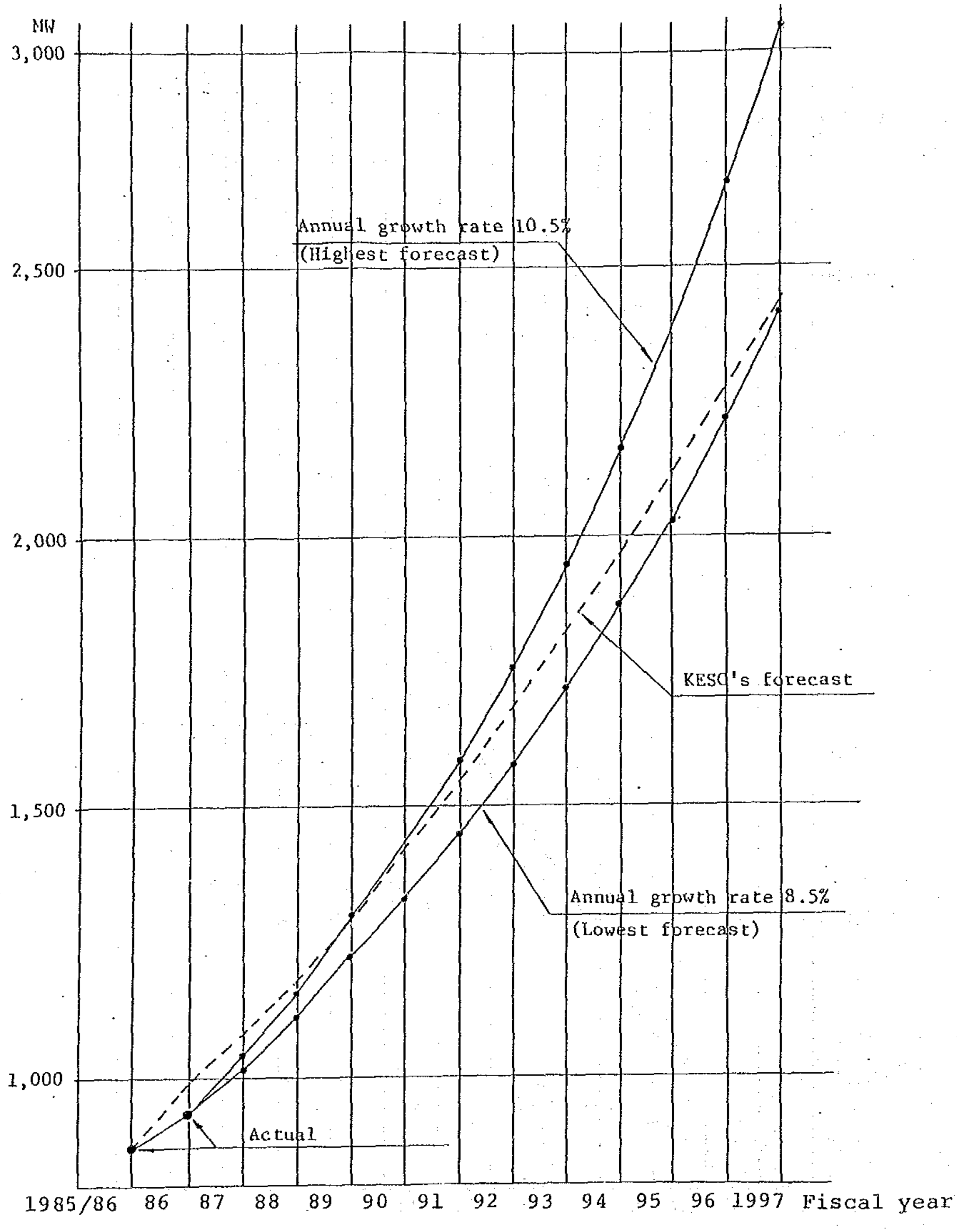


Fig. 3.5 Peak Demand Forecast (MW)



Chapter 4. POWER DEVELOPMENT PLAN

4.1 Power development plan

- Expansion of the Bin Qasim P.P. Unit 3 and Unit 4, each 210 MW, is now being carried out. The commissioning date was originally scheduled in June 1989 and October 1989 respectively, but taking into consideration the present situation, completion will be about four months behind schedule, meaning that the two units will be commissioned in October 1989 and February 1990.

  The contract for the Bin Qasim P.P. Unit 5, also 210 MW, will soon be awarded and this unit is scheduled to be commissioned in June 1991.

  Renewal work for the West Wharf P.P. and the Bin Qasim P.P. Unit 6 will follow the above project.

  Considering the very tight situation in energy balance in the early 1990's, these generation expansion programs following the Bin Qasim P.P. Unit 5 should be advanced as early as possible.

  Also, in view of system operation, the West Wharf P.P. occupies a better position than the Bin Qasim P.P. Unit 6. Without the West Wharf P.P., power sources will be too partially located in the KESC system, concentrating in the southeast section of the KECS supply area. As such, this might cause some difficulty in power system operation. The West Wharf P.P. is located in the west side and can maintain a good balance with the Bin Qasim P.P. in view of total system operation.

  However, because of difficulty of early retirement of the existing "BX" station of the West Wharf P.P., the development order of power sources after the Bin Qasin P.P. Unit 5 should be as follows.

Order	Expansion project	Commissioning date (planned)
1	West Wharf P.P. Unit 1 (200 MW)	Oct. 1992
2	Bin Qasim P.P. Unit 6 (210 MW)	Oct. 1993
3	West Wharf P.P. Unit 2 (200 MW)	Oct. 1984

On condition that the "BX" station is retired in Jan. 1992, when 220 kV transmission line between the Baldia grid station and the West Wharf P.P. will be commissioned.

4.2 Balance between supply and demand

Based on the above power development plan and the maximum demand forecast, the balance between supply and demand is determined as shown in Table 4.1 and Fig. 4.1.

As noted in this table and figure, the power and demand situation is very tight, even though the power development plan is on schedule. Particularly, in 1988 and 1989, several countermeasures, such as load shedding, load shift and/or suppression of new applicants, would be required until the Bin Qasim P.P. Units 3 and 4 are commissioned.

Also, against the firm capacity with one 200 MW unit out of service, the forecasted demand has little margin, sometimes over the firm capacity, in the next ten years.

After 1994, when the West Wharf P.P. Unit 2 is to be commissioned, power may be expected from WAPDA. If not, KESC should proceed with its expansion program by itself to meet the future demand.

Table 3.12 Balance between Demand and Supply

Year	KESC generation Installed capacity (MW)	KESC generation Actual capacity (MW)	Import KANAPP & PASMIC (MW)	Total available capacity (MW)	Reserve capacity (MW)	Firm capacity (MW)	Peak demand excluding WAPDA (MW)	Balance of demand and supply (Firm cap.) (MW)	Remarks
1	2	3	4	5(3+4)	6	7(5-6)	8	9(7-8)	
"Actual" 1986	1,108	1,039	70	1,109	200	909	945	(-) 36	(-) West Wharf: 'B' *(30/24 MW) retirement
87	1,108	1,039	70	1,109	200	909	1,086	(-) 177	
88	1,108	1,039	70	1,109	200	909	1,190	(-) 281	
89	1,528	1,459	70	1,529	200	1,329	1,304	(+) 25	(+) Bin Qasim: Units 3 & 4 (210 MW x 2)
90	1,723	1,658	70	1,728	200	1,528	1,429	(+) 99	(+) Bin Qasim: Unit 5 (210 MW) (-) Dual Fuel: *(15/11 MW) retirement
91	1,657	1,608	70	1,678	200	1,478	1,558	(-) 80	(-) West Wharf: 'BX' *(66/50 MW) retirement
92	1,857	1,808	-	1,808	200	1,608	1,698	(-) 90	(+) West Wharf: Unit 1 (200 MW) (-) KANAPP: (70 MW) retirement
93	2,057	2,018	-	2,018	200	1,818	1,834	(-) 16	(+) Bin Qasim: Unit 6 (210 MW)
94	2,257	2,218	-	2,218	200	2,018	1,981	(+) 37	(+) West Wharf: Unit 2 (200 MW)
95	2,257	2,218	-	2,218	200	2,018	2,139	(-) 121	
96	2,257	2,218	-	2,218	200	2,018	2,289	(-) 271	
1997	2,257	2,218	-	2,218	200	2,018	2,449	(-) 431	

* (Installed capacity/Actual capacity)

Fig. 4.1 Balance of Demand and Supply