Republic of Iraq

Ministry of Electricity

PREPARATORY STUDY FOR DEVELOPMENT OF SOUTHERN LARGE SCALE THERMAL POWER PLANT IN REPUBLIC OF IRAQ

FINAL REPORT

March 2012

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO ELECTRIC POWER SERVICES CO., LTD.
TOYO ENGINEERING CORPORATION
MITSUBISHI HEAVY INDUSTRIES, LTD.
UNICO INTERNATIONAL CORPORATION
MITSUI & CO., LTD.

Contents

Abbreviations

Abbreviations	Words
AC	Alternating Current
ACB	Air Circuit Breaker
ACC	Air Cooled Condenser
ADB	Asian Development Bank
AGC	Automatic Generation Control
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
B/C	Benefit/Cost
BCM	Billion Cubic Meters
BGS	Baghdad South
BOD	Biochemical Oxygen Demand
BOP	Balance of Plant
BPIE	Board of Protection & Improvement of Environment
BS	British Standard
BTU	British Thermal Unit
CAPEX	Capital Expenditure
CB	Circuit Breaker
CBR	California Bearing Ratio
CC	Combined Cycle
CCGT	Combined Cycle Gas Turbine
CCTPP	Combined Cycle Thermal Power Plant
CEMS	Continuous Emission Monitoring System
CBM	Condition-based Maintenance
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
C/P	Counterpart
CPA	Coalition Provisional Authority
CPU	Central Processing Unit
CT	Cooling Tower
CTG	Combustion Turbine Generator
DC	Direct Current
DCS	Distributed Control System
DE	Diesel Engine
D/F	Draft Final
DLN	Dry Low NOx
DSBO	Demand and Supply Balancing Operation
EA	Environment Assessment
EDI	Electrodeionizer
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation level
EMP	Environmental Management Plan
EOC	Effectuation of the EPC Contract
EOT	Equivalent Operating Time
EPC	Engineering, Procurement and Construction
ESD	Emergency Shutdown
EU	European Union
FCC	Fluid Catalytic Cracking

FIRR	Financial Internal Rate of Return
FOB	Free On Board
FOR	Forced Outage Rate
FS	Feasibility Study
GCB	Generator Circuit Breaker
GCB	Gas Circuit Breaker
GDP	Gross Domestic Product
GIS	Gas Insulated Switchgear
GL	Ground Level
GRS	Gas Regulation System
GSUT	Generator Step-up Transformer
GT	Gas Turbine
GTG	Gas Turbine Generator
HART	Highway Addressable Remote Transducer
HFO	Heavy Fuel Oil
HP-IP	High Pressure - Intermediate Pressure
HMI	Human Machine Interface
HP	High Pressure
HRD	Human Resource Development
HRSG	Heat Recovery Steam Generator
HSD	High Speed Diesel
IBA	Important Bird Area
IC	Interconnection
IDC	Interest During Construction
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IP	Intermediate Pressure
IP	Degree of Protection (IP Code) as per IEC 60529
IPB	Isolated Phase Bus
IPP	Independent Power Producer
IS	Iraqi Standard
ISB	Integral Shroud Blades
ISO	International Standard Organization
ITAO	Iraq Transition Assistance Office
IUCN	International Union for Conservation of Nature and Natural resources
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standard
KBA	Key Biodiversity Area
LCC	Life Cycle Cost
LCD	Liquid Crystal Display
LFC	Load Frequency Control
LLI	Long Lead-time Item
LNG	Liquefied Natural Gas
LOLE	Loss Of Load Expectation
LOLP	Loss Of Load Probability
LP	Low Pressure
LTSA	Long Term Service Agreement
LWL	Low Water Level
MCCB	Molded-case Circuit Breaker
MJ	mega joule
MOE	Ministry of Electricity

MOEN	Ministry of Environment
MOO	Ministry of Oil
MOV	Motor Operated Valve
MOWR	Ministry of Water Resources
MP	Master Plan
NAMUR	Interessengemeinschaft Automatisierungstechnik der Prozessindustrie (Automation Systems Interest Group of the Process Industry)
NCWRM	National Center for Water Resources Management
NERC	North American Electric Reliability Corporation
NGO	Non-Governmental Organization
NI	Nature Iraq
NOx	Nitrogen Oxide
NTP	Notice to Proceed
O&M	Operation and Maintenance
ODA	Official Development Assistance
ODC	Over Dimension Cargo
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
OTS	Operator Training Simulator
PB	Parsons Brinckerhoff
PDP	Power Development Planning
PDPAT II	Power Development Planning Assist Tool (Software name)
PLC	Programmable Logic Controller
PO	Purchase Order
PM	Particulate Matter
PM	Predictive Maintenance
ppm	Parts per million
PPS	Power Producer and Supplier
Pre-FS	Pre-Feasibility Study
P/S	Power Station
PSS/E	Power System Simulator for Engineering (Software name)
RC	Reinforced Concrete
RO	Reverse Osmosis
SCADA	Supervisory Control And Data Acquisition
SCF	Standard Cubic Feet
SER	Sequence of Events Recording
SI	The International System of Units
SOx	Sulfur Oxide
SPM	Suspended Particulate Matter
SPT	Standard Penetration Test
S/S	Single Shaft
SS	Suspended Solid
ST	Steam Turbine
STG	Steam Turbine Generator
S/W	Scope of Work
TDS	Total Dissolved Solids
TEPCO	Tokyo Electric Power Company, Inc
TEPSCO	Tokyo Electric Power Services Co., Ltd.
TEQ	Toxic Equivalent
TNC	The Nature Conservancy
TOC	Total Organic Carbon
TOR	Terms Of Reference
TPP	Thermal Power Plant

TQM	Total Quality Management
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UAT	Unit Auxiliary Transformer
UBC	Uniform Building Code
UF	Ultra-filtration
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UPS	Uninterruptible Power Supply
US	United States
USA	United States of America
USCS	Unified Soil Classification System
USD	United States Dollar
VCB	Vacuum Circuit Breaker
WASP IV	Wien Automatic System Planning (Software name)
WB	World Bank
WHO	World Health Organization
WHS	World Heritage Site
WTP	Willingness to Pay
WWF	World Wide Fund for Nature
XLPE	Cross-linked Polyethylene
ZLD	Zero Liquid Discharge

List of Figures

List of Photos

List of Tables

Chapter 1

Introduction

Chapter 1 Introduction

1.1 Background of the Study

Iraq had only total available capacity of power plants of 6,800MW against power demand of 10,000MW as of 2008. Therefore, serious power shortages had been caused by decline of the capacity of power generation and power network facilities, unstable fuel supply, difficulties of procurement of spare parts in the aged power plants, stagnation of investment in new power development and so on, in consequence of the War. Besides, the largest power demand area is Bagdad, the national capital of Iraq, and industrial zones in Southern and Northern area also became major power demand area.

Since function of the power sector had depressed significantly in consequence of the long-term War despite that the power sector is a basic infrastructure for all economic and social activities, reconstruction of the power sector is stated as one of the primary roles in the National Development Strategy in Iraq, published in February 2007.

The power sector is a strategic field of Japan ODA in Iraq, and Japan has supported the following projects through its Yen loan, “Al-Mussaib Thermal Power Plant Rehabilitation Project”, “Electricity Sector Reconstruction Project”, and "Al-Akkaz Gas Power Plant Construction Project”..

Since power supply to the basic infrastructures such as waterworks, hospitals and civic life is unstable and power outage of more than 10 hours in a day occurs in the most area in Iraq, support needs for the power sector, particularly need full-scale repair works, new power generation projects are growing. Therefore, Iraqi government requested a Yen Loan Project of "Southern large-scale thermal power plant development project" (hereinafter "the Project") to Japan's Government. In response, from July 2007 to June 2008, the former JBIC conducted Pre-Feasibility Study for the 17 candidate sites and selected Shat Al-Basra as the promising candidate site for a power plant development.

There are some problems in the power sector in Iraq that planned maintenance of power generation, transmission and distribution facilities is not performed and electricity tariff is not enough to cover the operational costs of the facilities and so on. In order to improve generating capacity which has not been absolutely improved so far, Ministry of Electricity in Iraq started recently to prepare introduction of regulations which implies to develop generating facilities by independent power producers (IPPs). IPP investment conferences were held in Jordan in Nov. and Dec. 2008, it was stated that power development projects for IPP would be incorporated into the Iraq Electricity Master Plan hereafter. In the same conference, Shat Al-Basra, the priority project site, was listed up as a development project by IPP which is implemented in 2011 in the abstract of power sector MP that was presented by Ministry of Electricity in Iraq. As for the electricity tariff, averaged electricity selling price is hiked from 2.5 Iraqi dinar (0.21 UScent/kWh) to 27 Iraqi dinar (2.3 UScent/kWh), and is planned to be raised up to 85 Iraqi dinar (7 US cents / kWh) in the future.

The conducting organization of the Project is Ministry of Electricity in Iraq (hereinafter referred to as MOE), which has responsibility for operation and maintenance of power facilities and equipment and associated regulations. Meanwhile, neither corporation nor privatization is scheduled in the near future. The Ministry of Electricity had carried out feasible maintenance works including routine repairs, etc., under severe constraints during the several disputes and sanctions period, and has potentially high technical capabilities and staff of approximately 70,000 people. There are approximately 12,000 staffs in the power network department and approximately 30,000 staffs in the distribution department, and 15% of staffs in each department are engineers.

Since the Government of Iraq requested the Project to the Government of Japan as a new candidate of the Yen loan project, the Study is carried out to prepare Feasibility Study Report for approval of a new Yen loan project.

1.2 Purpose of the Study and Implementation Details

1.2.1 Purpose of the Study

The purpose of the Study is to conduct Feasibility Study on the priority power plant development site, which is selected among power plant candidate sites in Pre-Feasibility Study, by collecting necessary information for appraisal of Yen loan regarding the thermal power development of 1,200MW class[1] in the Southern region of Iraq.

1.2.2 Area in Which to Conduct the Study

The Study is to be conducted in the Southern region of Iraq.

1.2.3 Scope of the Study Works

The Study will be conducted in the four stages and study items in each stage are shown in Table 1-2-1.

Table 1-2-1 Scope of the Study Works

STAGE	Study Items
STAGE-1 Basic Investigation	a. Collecting, checking and analyzing related data [Preparation work in Japan, 1st study in Amman and 1st work in Japan] b. Reviewing Pre-Feasibility Study report on candidate sites of large scale southern TPP and selecting likely candidate sites [Preparation work in Japan and 1st study in Amman] c. Preparing implementation structure and work plan for additional investigation on selected likely candidate sites and topographical / geological investigation and hydrological / environmental survey on F/S site [Preparation work in Japan] d. Preparing Inception Report and consulting it with counterparts [Preparation work in Japan and 1st study in Amman] e. Preparing contract documents to employ local consultants and contracting with local consultant [Preparation work in Japan and 1st study in Amman]
STAGE-2 Selection of F/S Object Site	a. Collecting and checking and analyzing results of additional investigation on likely candidate sites [1st work in Japan] b. Prioritizing likely candidate sites [1st work in Japan] c. Preparing selection report and consulting it with counterparts [1st work in Japan and 1.5th study in Amman] d. Preparing investigation plan of topography, geology, hydrology and environment and consulting it with counterparts [1st work in Japan, 1.5th study in Amman] e. Assisting to hold 1st Stakeholder meeting [1st work in Japan]
STAGE-3 Feasibility Study	a. Managing investigation works of topography, geology, hydrology and environment [2nd study in Amman, 2nd work in Japan] b. Optimizing sort of fuel, generating system and unit capacity in accordance with

[1] During the Preparatory Study period, MOE Team changed its target of the installed capacity from 1,200MW to 1,800MW as stated in Chapter 4, 4.1 “Basic concept”.

	demand and supply balance simulation and power system analysis [2nd study in Amman and 2nd work in Japan] c. Examining cooling system and layout of intake and outlet facilities and conducting thermal discharge simulation [2nd and 3rd study in Amman and 2nd and 3rd work in Japan] d. Examining Facility Design [2nd and 3rd study in Amman and 2nd and 3rd work in Japan] e. Scoping and surveying environment and social consideration [2nd and 3rd study in Amman and 2nd and 3rd work in Japan] f. Preparing Inception Report and consulting it with counterparts [2nd work in Japan and 3rd study in Amman] g. Studying project implementation structure and system for operation and maintenance [3rd study in Amman and 3rd work in Japan] h. Studying economic and financial analysis and operation and effect indicators[3rd study in Amman and 3rd work in Japan]
STAGE-4 Implementation Program Study	a. Arranging study results of Southern large-scale power plant [3rd work in Japan] b. Arranging survey and assessment results of environment and social consideration [3rd work in Japan] c. Assisting to hold 2nd Stakeholder meeting [3rd work in Japan] d. Preparing Draft Final Report and consulting it with counterparts [3rd work in Japan] e. Preparing Final Report [4th work in Japan]

1.3 Study Organization and Study Achievements

1.3.1 Conducting Organizations of the Partner Country

Ministry of Electricity (MOE), the Government of Republic of Iraq

1.3.2 Composition of Study Group and their Study Schedule

This Study will be executed with the members and system as shown in the Figure 1-3-1.

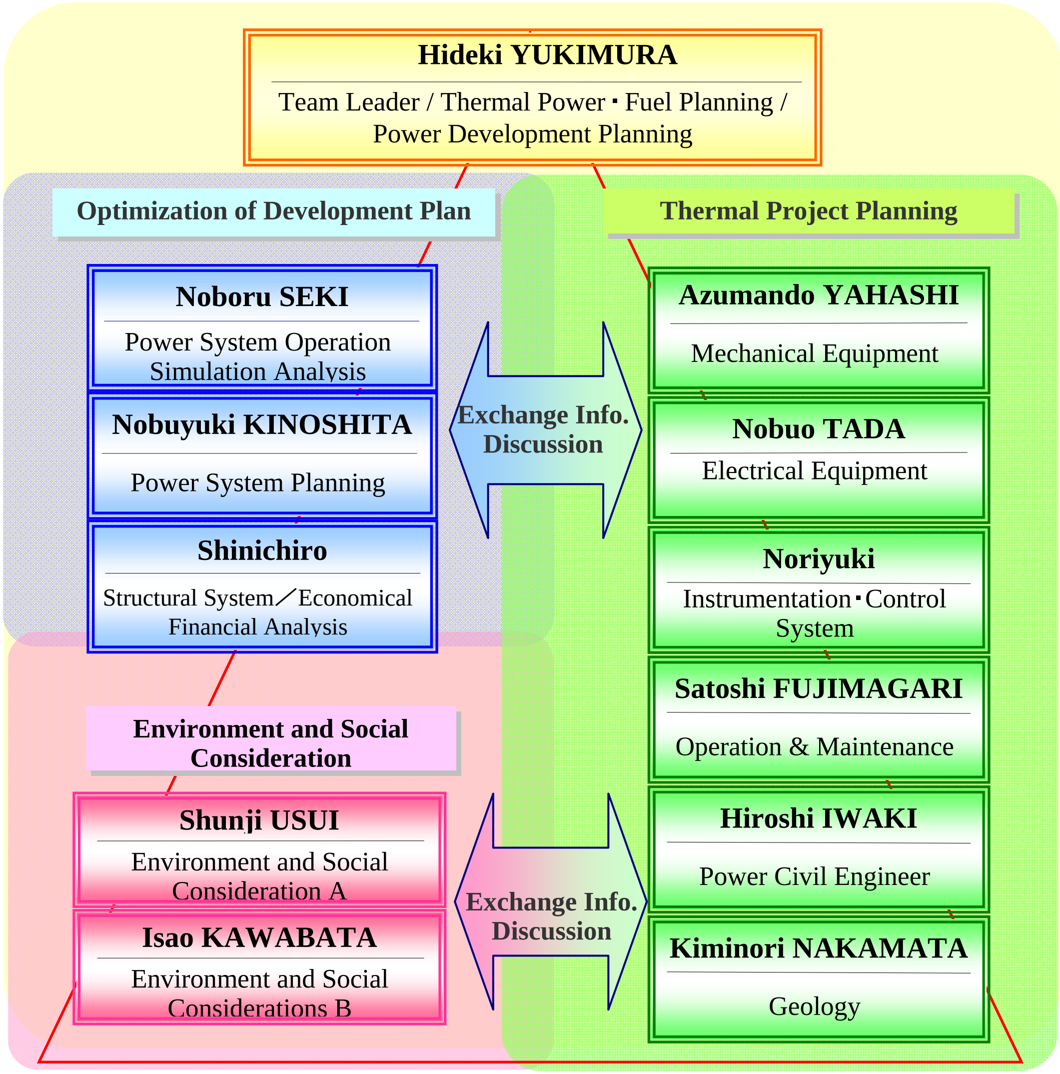


Figure 1-3-1 Organization of Study Team[2]

1.3.3 Study Achievements

The first mission in Amman was conducted in July 2011.

1) The inception report was briefed and discussed.
2) Related data and information were collected and verified.
3) Pre-conditions for the Study were confirmed.
4) 3 Likely candidate sites were selected.
5) Required additional data and information of 3 likely candidate sites for Feasibility Study site selection were mutually confirmed.

The 1.5th mission in Amman was conducted in August 2011.

[2] Mr. YUKIMURA replaced Mr. Ito at the team leader position on October 2011. Mr. Ito had been responsible to manage only the 1st and 1.5th missions.

1) Feasibility study site was selected among 3 likely candidate sites.
2) Construction site survey plan for the FS was mutually confirmed.
3) EIA study plan and time frame of EIA were discussed.

The second mission in Tokyo was conducted in October 2011.

1) The contents of Interim Report on the study were discussed.
2) EIA study plan and time frame of EIA were discussed.

The third mission in Amman was conducted in November 2011.

1) Follow-Up EIA Study was discussed.
2) Plant Design was discussed.
3) Project Implementation was discussed

The 3.5th mission in Amman was conducted in January 2012.

1) The contents and the schedule of the draft EIA Report were confirmed.

The fourth mission in Istanbul was conducted in February 2012.

1) Hydrological and Meteorological issues were discussed.
2) Facilities Design was discussed
3) Project Cost was discussed.
4) Operation and Maintenance were discussed.
5) Economic and Finance Analysis were discussed.
6) The contents and the schedule of the draft EIA Report were confirmed.
7) Bandirma CCTPP visit.

Detail study achievements of each mission refer to Attachment -1.

Chapter 2

Energy Sector and Electricity Sector

Chapter 2 Energy Sector and Electricity Sector

2.1 Energy Sector

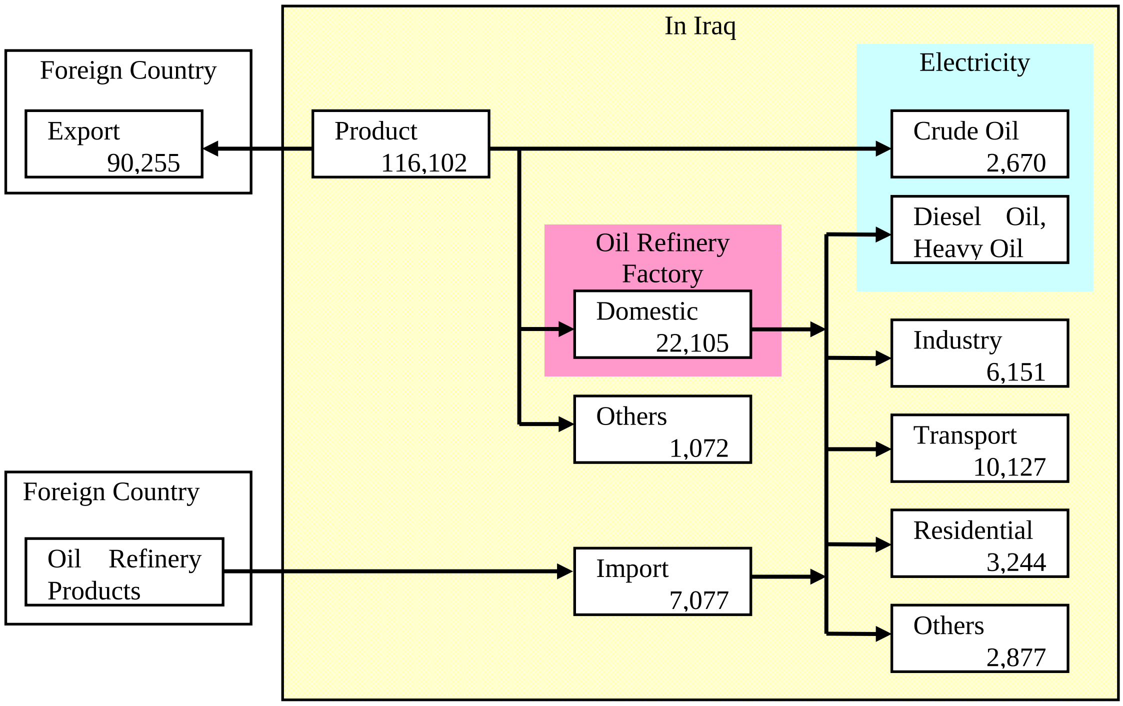
2.1.1 Situations Surrounding Energy

(1) Oil

Figure 2-1-1 shows demand and supply balance of crude oil in Iraq in 2008.

Production of crude oil is 116 million tons (oil equivalent) and 78% of that is exported to out of the country. Around 2% of that is combusted directly for power generation. Although around 19% of that is refined into gasoline, diesel oil, heavy fuel oil, etc. in the domestic refinery factories, the amount of oil product refined in the domestic refinery factory is not enough to meet the domestic demand. Therefore, one fourth of the demand is supplied by importation from abroad. Around 28 % of oil refinery products such as diesel oil and heavy fuel oil (HFO) are used for power generation.

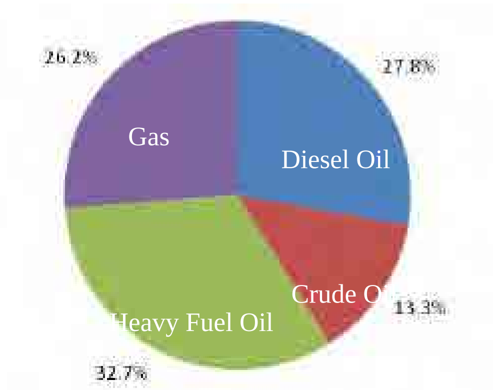
Unit: 1000 ton (Oil equivalent)



Source: Energy Balance (IEA)

Figure 2-1-1 Demand and Supply Balance of Crude Oil in Iraq in 2008

Composition of fuel for power generation in 2009 is shown in Figure 2-1-2.

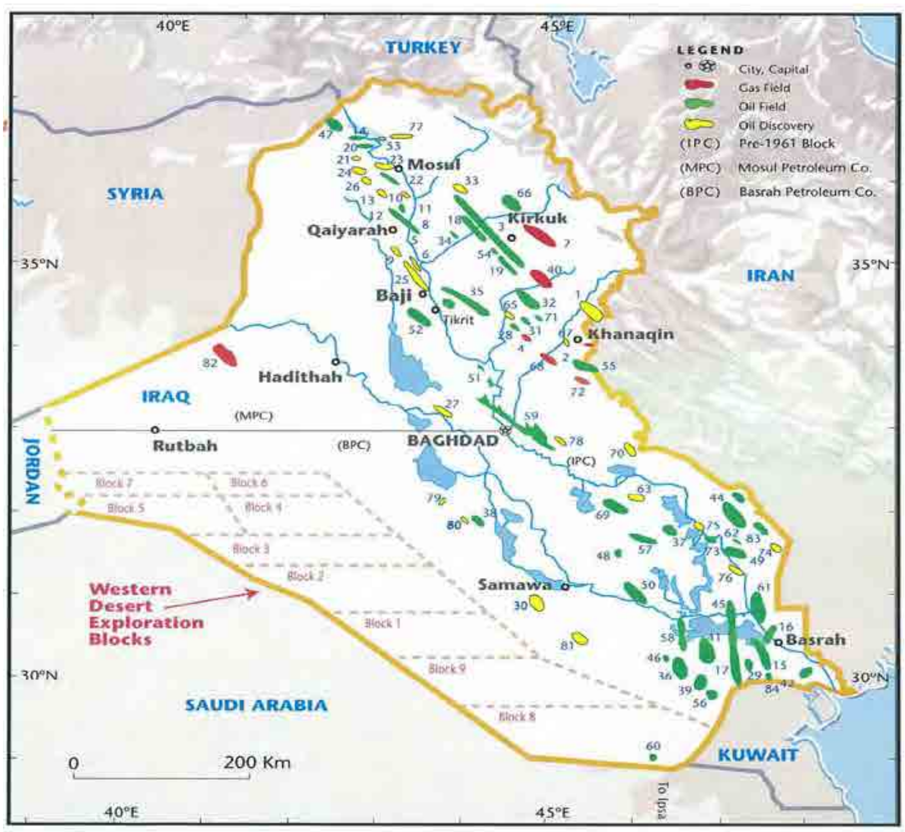


Source: Master Plan Conference (February 2011)

Figure 2-1-2　Composition of Fuel Used for Generation in 2009

Crude oil accounts for 13.3% of the total fuel consumption for power generation. If this amount of crude oil is alternated by others, the more crude oil can be exported than at present.　Besides, although diesel oil accounts for 27.8%, since a part of the whole use amount of diesel oil is imported, it is desirable to be alternated by others as much as possible.　The estimated average consumption of gas and HFO used for thermal power generation are 430 million SCF/day and 15,000 ton/day respectively, both figures are only half of the available amount.

Figure 2-1-3 shows distribution of the oil fields in Iraq.　Many oil fields are distributed in the South region and one of three major refineries in Iraq exists in the Basra.



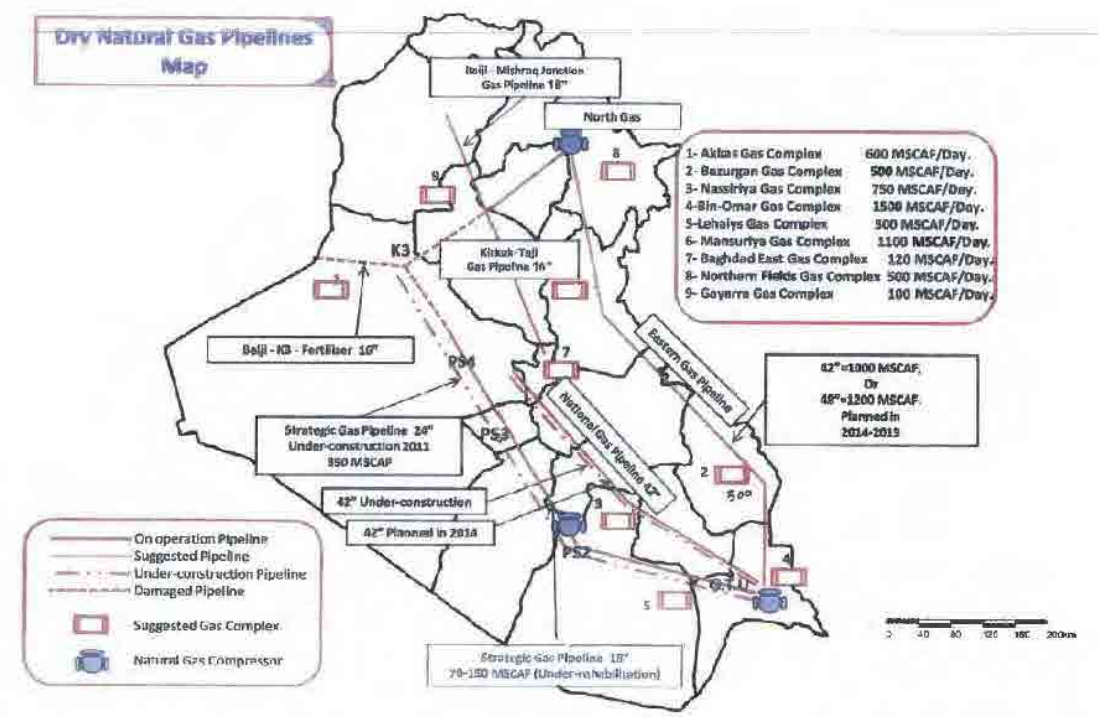
Source: Energy Intelligence Research

Figure 2-1-3　Distribution of Oil Fields in Iraq

(2) Natural Gas

It is estimated that there is 70% of gas reserves in the Basra area. Figure 2-1-4 shows the gas pipeline development plan. There is a natural gas compressor station in the Basra, and three gas pipeline systems between the north and the south (Basra) are newly planned to enhance the gas distribution capacity over the country.

The South region has sufficient gas and HFO production for power generation, and also every infrastructure such as gas pipelines, oil refineries, and gas compressor stations.



Source: Master Plan Final Report (December 2010)

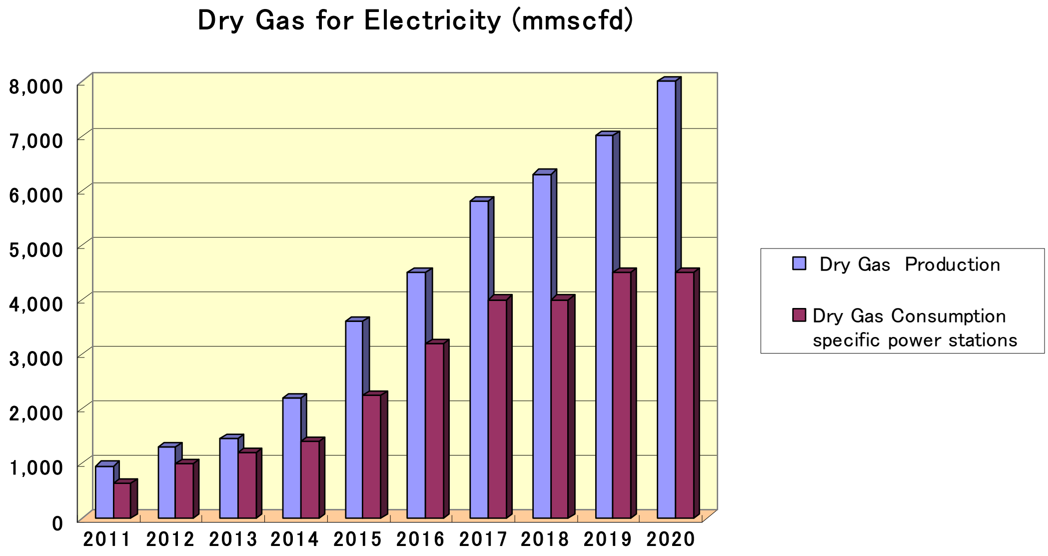
Figure 2-1-4 Development Plan of Gas Pipelines

2.1.2 Energy Demand and Supply

(1) Natural Gas

It is a national energy policy that indigenous natural gas is supplied for power generation as a first priority.

Natural gas reserve is inferred to be abundant, production of natural gas in 2011 is only 960 mmscfd and 646 mmscfd (67.3%) is used for electricity generation. Meanwhile, natural gas (including associated gas) production is growing rapidly up to around 8,000 mmscfd in 2020 which is 8 times of that in 2011, as shown in Figure 2-1-5 and 60 to 70 percent of production is planned to be used for fuel of gas thermal power plants for base load. In other words, the gas thermal power plants are planned to be developed remarkably from 2,200MW in 2011 to 16,000MW in 2020.

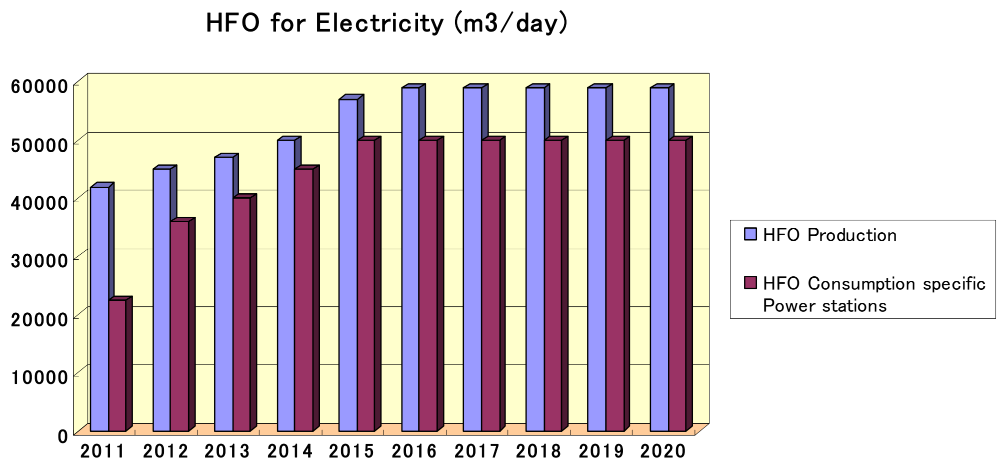


Source: Ministry of Oil

Figure 2-1-5 Demand and Supply Balance of Dry Gas in Iraq

(2) Heavy Fuel Oil (HFO)

Heavy Fuel Oil (HFO) production is also growing gradually for next 5years from 42,000m3/day in 2011 to 57,000m3/day in 2015. After that, the production rate is expected to be constant. Meanwhile, the share of production for electricity generation is increasing rapidly as shown in Figure 2-1-6, from 50% in 2011 to 85% in 2015.



Source: Ministry of Oil

Figure 2-1-6 Demand and Supply Balance of HFO in Iraq

2.2 Power Sector

2.2.1 Review of Power Demand Forecast and Power Development Plan

In December, 2010, the final report on Iraqi Power Development Master Plan was released by Parsons Brinckerhoff (PB) who was assigned by MOE as a consultant. The Master Plan study was financed by the US Government State Department and executed under the supervision of the State Department's Iraq Transition Assistance Office (ITAO) and MOE.

The Master Plan (MP2010) illustrates the power demand forecast and power development plan as follows;

(1) Current status of power demand and supply

The power demand in 2010 is expected to reach approximately 12,000MW assuming Iraqi power system is well developed as planned. Meanwhile, the installed capacity in 2010 is only 9,700MW including 700MW of the electricity imported from Iran. However, the reliable installed capacity could be lower than 9,000MW due to the problem of the high forced outage rate recorded in Iraqi system. Therefore, LOLP (Loss of Load Probability) is likely to be 72%. It means that load shedding has frequently occurred in 6,300 hours of 8,760 hours in a year.

(2) Power demand forecast

In the Master Plan, 7% GDP growth and accordingly huge power demand are expected even after 2011 as per the below figure.

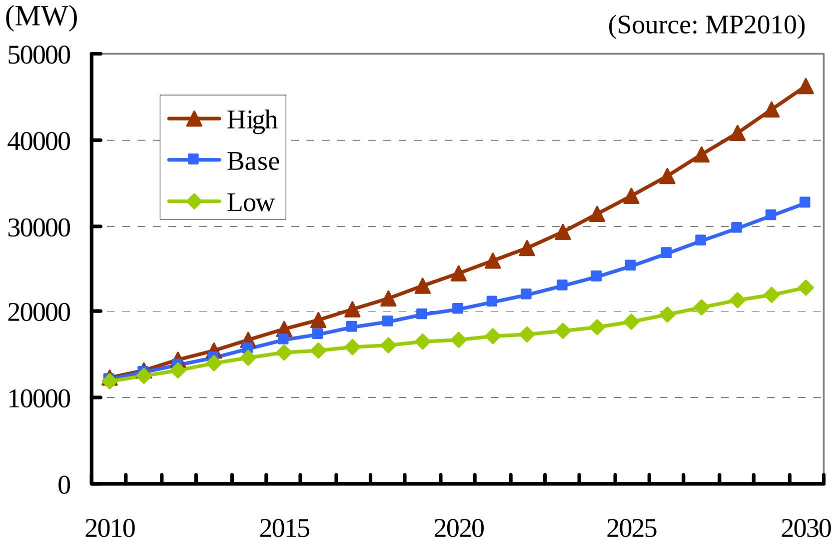


Figure 2-2-1 Demand Forecast

In Base Case, the electricity demand should be increased by 20,000MW in 20 years. It means that the power demand increases by 1,000MW in every year.

(3) Power development plan

The principle of Iraqi Power Development Master Plan is as follows;

- Target of LOLP is 0.3% to ensure reliable power supply in future. This is equivalent to 26 hour a year at LOLE (Loss of Load Expectation) figure.
- Short term development of simple cycle gas turbine power generating plants is urgent to eliminate recent power shortage. These power plants should be fueled by utilizable resources nearby for the short term regardless fuel type and cost effectiveness.
- The fuel should be converted to gas in consideration of cost effectiveness by developing gas pipeline systems in succeeding years
- Since the simple cycle gas turbine (GT) power plant is low in thermal efficiency, upgrading to the combined cycle gas turbine power plant is planned by adopting a steam turbine to the existing two gas turbines in order to improve its thermal efficiency.

In Iraqi power system, it is anticipated to additionally develop the power generation capacity at approximately 1,300MW in every year to meet the increasing power demand. The electricity demand and the installed power generating capacity until 2030 are estimated as shown in Figure 2-2-2.

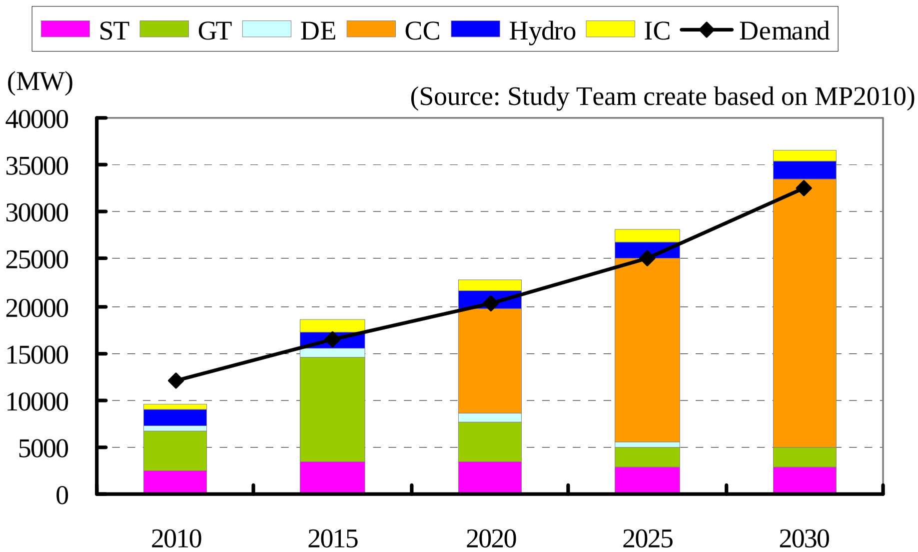


Figure 2-2-2 Relation between Maximum Demand and Installed Capacity

CCTPP will account for 78% of Iraqi power generating capacity in 2030 since the existing GTs can be upgraded to CCTPP and additional CCTPP plants can be newly installed after 2016. Gas consumption will increase by replacing other fuel like HFO and, in consequence, it will account for 65% of Iraqi fuel consumption in 2020 and 84% in 2030 respectively.

The below chart shows the trend of the average figures of thermal efficiency of Iraqi thermal power plants.

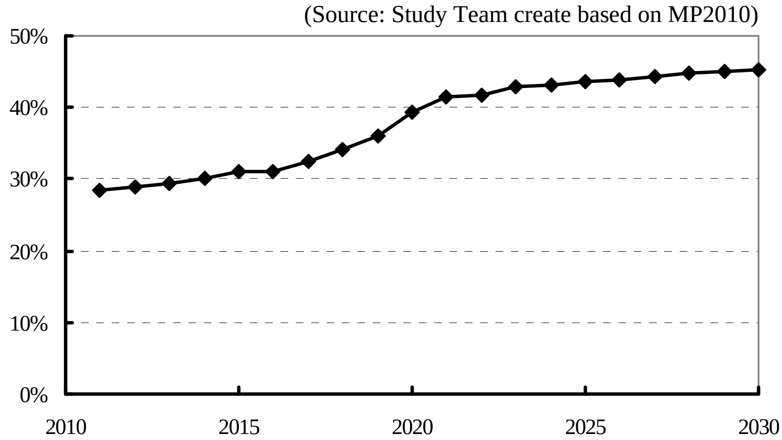


Figure 2-2-3 Trend of Thermal Efficiency

The thermal efficiency is supposed to be about 30% until around 2015 because the low-efficiency GT power plants will have been in operation for the urgent power supply purpose. After 2016, upgrading the existing GT power plants to CCTPPs is planned by adding steam turbines and generators, and in addition, some CCTPPs are planed to be newly installed to the grid. Consequently, the thermal efficiency over the Iraqi power system would be dramatically improved by 40% in 2020.

In the 2020s, the thermal efficiency could be gradually improved and eventually reach to 45% in 2030.

(4) Regional power demand and supply

Table 2-2-1 shows maximum demand record (2009 estimated value) in each region in Iraq excluding Kurdish autonomous area.

Table 2-2-1 Maximum Demand (Region-wise)

(Unit: MW)

North		Baghdad		Central		South		Total
Al Anbar	373	Baghdad	3,002	Babil	422	Missan	310	
Diyala	282			Al Qadisiyah	344	Basrah	1,045	
Nineveh	964			Karbala	300	Dhi Qar	459	
Salah ad Din	436			Wasit	287	Al Muthana	230	
Kirkuk	367			Al Najaf	400			
	2,422		3,002		1,753		2,044	9,221
	26.3%		32.6%		19.0%		22.2%	100%

(Source: Study Team create based on MP2010)

Assuming the future power demand in each region is increased proportionately, demand-supply balance in each region and year is expected as below.

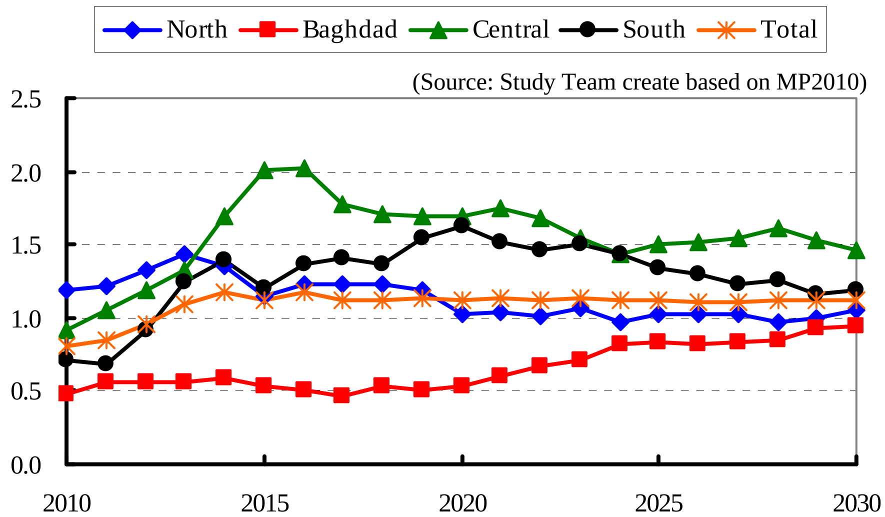


Figure 2-2-4 Demand and Supply Balance (Region-wise)

In Baghdad area, the power generating capacity is in short and can not meet the power demand. Therefore, large amount of electricity needs to be accommodated from the central region of Iraq.

2.2.2 Power Network Systems

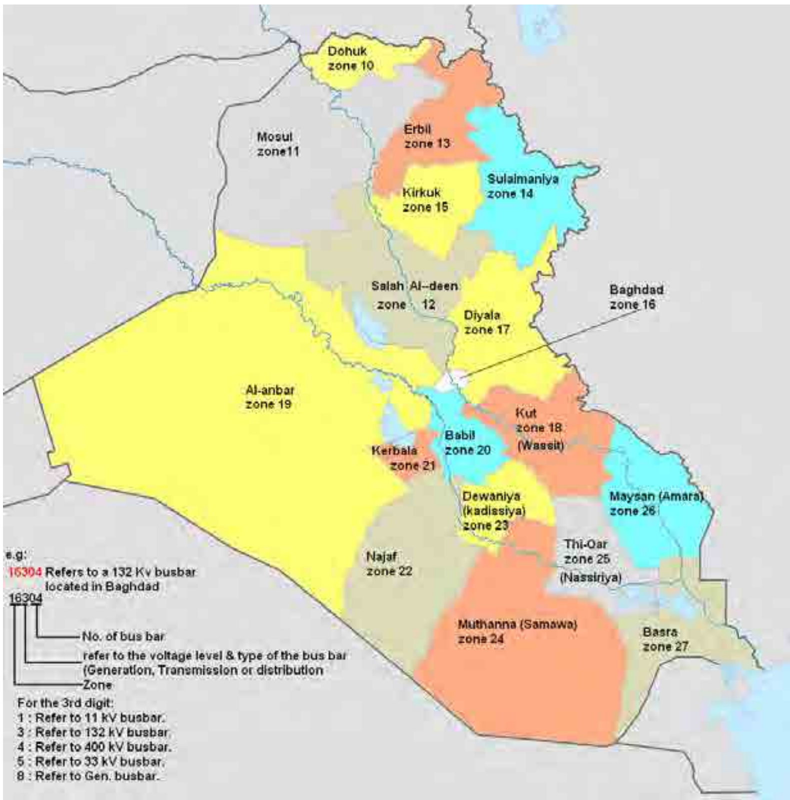
(1) Regions and areas in Iraq

Iraq is divided into 6 regions and 18 sub-regions as shown in Figure 2-2-5. Table 2-2-2 shows the relationship between regions and sub-regions.

Table 2-2-2 Regions and Sub-regions in Iraq

Region	No.	Sub-region Name	Region	No.	Sub-region Name
1. North	10	Duhok	4. West	19	Al-anbar
	11	Mosul	5. South-west	20	Basil
	12	Salah Al-deen		21	Kerbala
2. East	13	Erbil		22	Najaf
	14	Sulaimaniya		23	Dewaniya (Kadissiya)
	15	Kirkuk	6. South	24	Muthanna (Samawa)
3. Central	16	Baghdad		25	Thi Qar (Nasiryah)
	17	Diyala		26	Maysan (Emara)
	18	Kut		27	Basra

Source : MOE



Source : MOE

Figure 2-2-5 Sub-regions in Iraq

(2) Regional demand and supply balance

The Study Team analyzed the network data provided by MOE with PSSE and figured out the regional demand and supply balance as shown in Table 2-2-3.

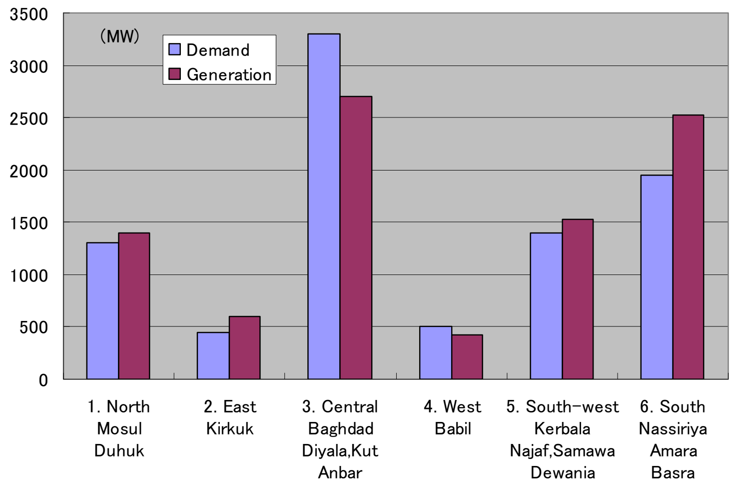
The total demand is 8,891MW excluding the effects from the power interchange among neighboring countries, transmission loss and station service power. Central region, which capital city is Baghdad with more than 5 million populations, accounts for 36% of the total demand, and Southern region, which has the second largest city Basra, accounts for 22%. Hence, Central and Southern regions account for about 60% of total demand.

Meanwhile, Central and Southern regions have 29% and 28% of the total power generation capacity over the country (9,161MW), respectively. Accordingly, the power is transmitted from Southern region (power surplus area) to Central Region to meet the demand in Central region as shown in Figure 2-2-6 and 2-2-7.

Table 2-2-3 Demand and Supply Balance by Region in 2011

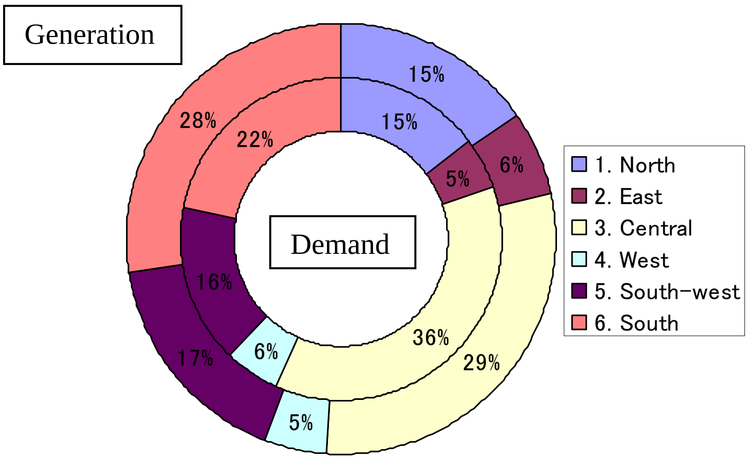
Region	Demand (MW,(%))	Generation (MW, (%))
1. North	1,299 (15%)	1,395 (15%)
2. East	445 (5%)	594 (6%)
3. Central	3,296 (36%)	2,701 (29%)
4. West	503 (6%)	426 (5%)
5. South-West	1,394 (16%)	1,522 (17%)
6. South	1,954 (22%)	2,523 (28%)
Total	8,891 (100%)	9,161 (100%)

Source：PSSE data from MOE



Source：PSSE data from MOE

Figure 2-2-6 Demand and Supply Balance by Region in 2011



Source : PSSE data from MOE

Figure 2-2-7 Demand and Supply in 2011

(3) Power network system

In Iraq, the 400kV network has performed as the interconnection line for interactively transmitting power among regional power systems that are configured by 132kV network systems.

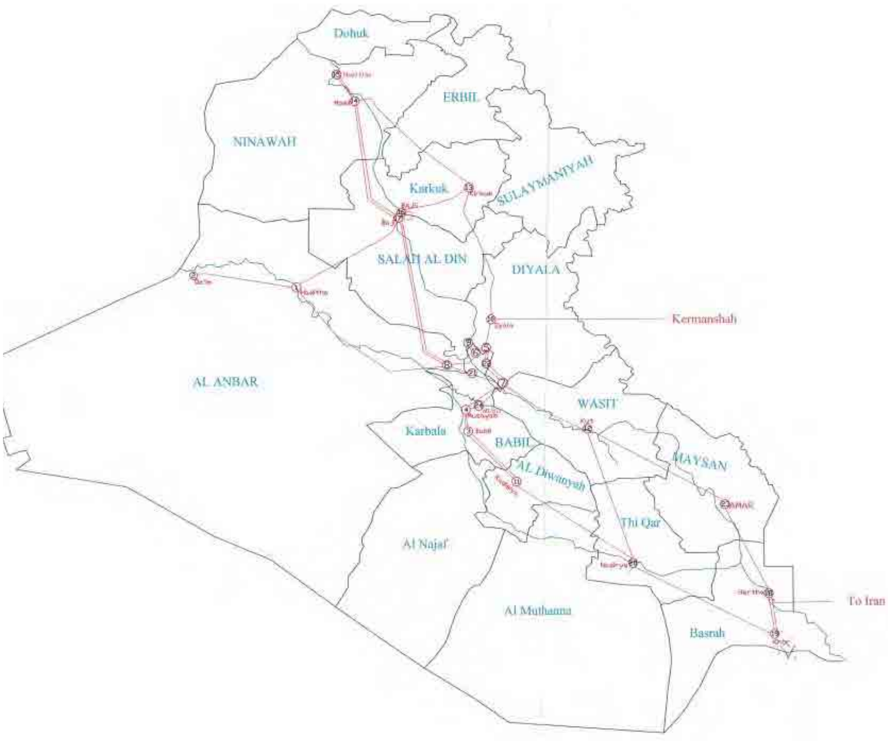
Figure 2-2-8 shows 400kV bulk power network as of 2011. Two 400kV single circuit transmission lines run between Basra and Baghdad with the length of about 500km transmitting power generated by the major power plants in southern Iraq.

Other two 400kV transmission lines run in northern Iraq with the length of about 400km between Mosil and Baghdad. The western line has two circuits and the eastern one is a single circuit. There are 3 circuits in total connecting North regional system and Central regional system.

Moreover, the Iraqi power system has been interconnected with Iranian power system by a 400kV single circuit transmission line at Dyala substation located in Central region.

(a) Transmission

Table 2-2-4 shows the existing 400kV transmission lines. The total length of 400kV transmission lines reaches approximately 4,300km. The total transmission capacity of all 400kV lines is about 1,000MVA or 950MW (power factor 0.95 assumed) . This figure is considered relatively small.



Source : MOE

Figure 2-2-8 Power Network System in 2011

Table 2-2-4 Existing 400kV Transmission Line

From	To	No. of circuit	Capacity per circuit (MVA)	Length (km)	From	To	No. of circuit	Capacity per circuit (MVA)	Length (km)
MSL	MMDH	1	1,000	63	BGE	AMN	2	1,000	20
MSL	MMDH	2	1,000	63	BGE	DAL	1	1,000	40
MSL	BAJP	1	1,000	184	BGN	QDSG	1	1,000	7
MSL	BAJP	2	1,000	184	BGN	QDSG	2	1,000	7
MSL	KRK	1	1,000	220	AMN	KUT	1	1,000	140
BAJP	BAJG	1	1,000	1	AMN	KDS	1	1,000	160
BAJP	BGW	1	1,000	223	DAL	IRAN-ZGRS0	1	1,000	324
BAJP	BGW	2	1,000	229	KUT	NSRP	1	1,000	199
BAJP	HDTH	1	1,000	159	KUT	AMR	1	1,000	221
BAJG	KRK	1	1,000	83	HDTH	QIM	1	1,000	128
KRK	DAL	1	1,000	196	MUSP	MUSG	1	1,000	5.5
BGW	BGN	1	1,000	43	MUSP	BAB	1	1,000	36
BGW	BGC	1	1,000	29	MUSP	BAB	2	1,000	36
BGW	HDTH	1	1,000	224	BAB	KDS	1	1,000	102
BGS	AMN	1	1,000	38	BAB	KDS	2	1,000	102
BGS	AMN	2	1,000	38	KDS	NSRP	1	1,000	177
BGS	BGC	1	1,000	45	NSRP	KAZG	1	1,000	203
BGS	MUSP	1	1,000	54	AMR	HRTP	1	1,000	134
BGS	MUSG	1	1,000	48	HRTP	KAZG	1	1,000	55
BGE	BGN	1	1,000	13	MUHAMARRA	KAZG	1	1,000	50
BGE	AMN	1	1,000	20	Total circuit length (km)				4,300

Source : MOE

(b) Substation

Table 2-2-5 shows the existing 400kV substations. At present, there are twenty 400kV substations, and the standard specification of the transformers is 400/132kV or 250MVA. There are 64 transformers over the country. Each substation has 4 transformers as standard.

It is noted that 9 out of 64 transformers are in outage. It means that 2,250MVA out of 16,000MVA has been lost for the transformer capacity.

Table 2-2-5 Existing 400kV substation

Substation name	Unit number	In Service ○ : In × : Out	Capacity (MVA)	Substation name	Unit number	In Service ○ : In × : Out	Capacity (MVA)
Mosil	1	○	250	Kut	1	○	250
	2	○	250		2	○	250
	3	○	250	Haditha	1	○	250
	4	×	250		2	○	250
Baji	1	○	250	Qaim	1	○	250
	2	○	250		2	○	250
Kirkuk	1	○	250	Musayab	1	○	250
	2	○	250		2	○	250
	3	○	250		3	×	250
	4	○	250		4	○	250
Baghdad West	1	○	250	Babil	1	○	250
	2	○	250		2	○	250
	3	○	250		3	○	250
	4	○	250		4	○	250
Baghdad South	1	○	250	Kadisiya	1	○	250
	2	×	250		2	×	250
	3	○	250		3	○	250
	4	○	250		4	○	250
Baghdad East	1	○	250	Nasiryah	1	○	250
	2	○	250		2	○	250
	3	○	250	Hartha	1	○	250
	4	○	250	Amar	1	○	250
Baghdad North	1	○	250		2	○	250
	2	○	250	Khor	1	○	250
	3	○	250		2	○	250
	4	×	250		3	○	250
Amen	1	○	250	Baghdad Center	1	○	250
	2	×	250		2	○	250
	3	×	250		3	×	250
	4	○	250		4	×	250
Dyala	1	○	250				
	2	○	250				
	3	○	250	Total (In-service)			13,750
	4	○	250	Total (Out-of-service)			2,250

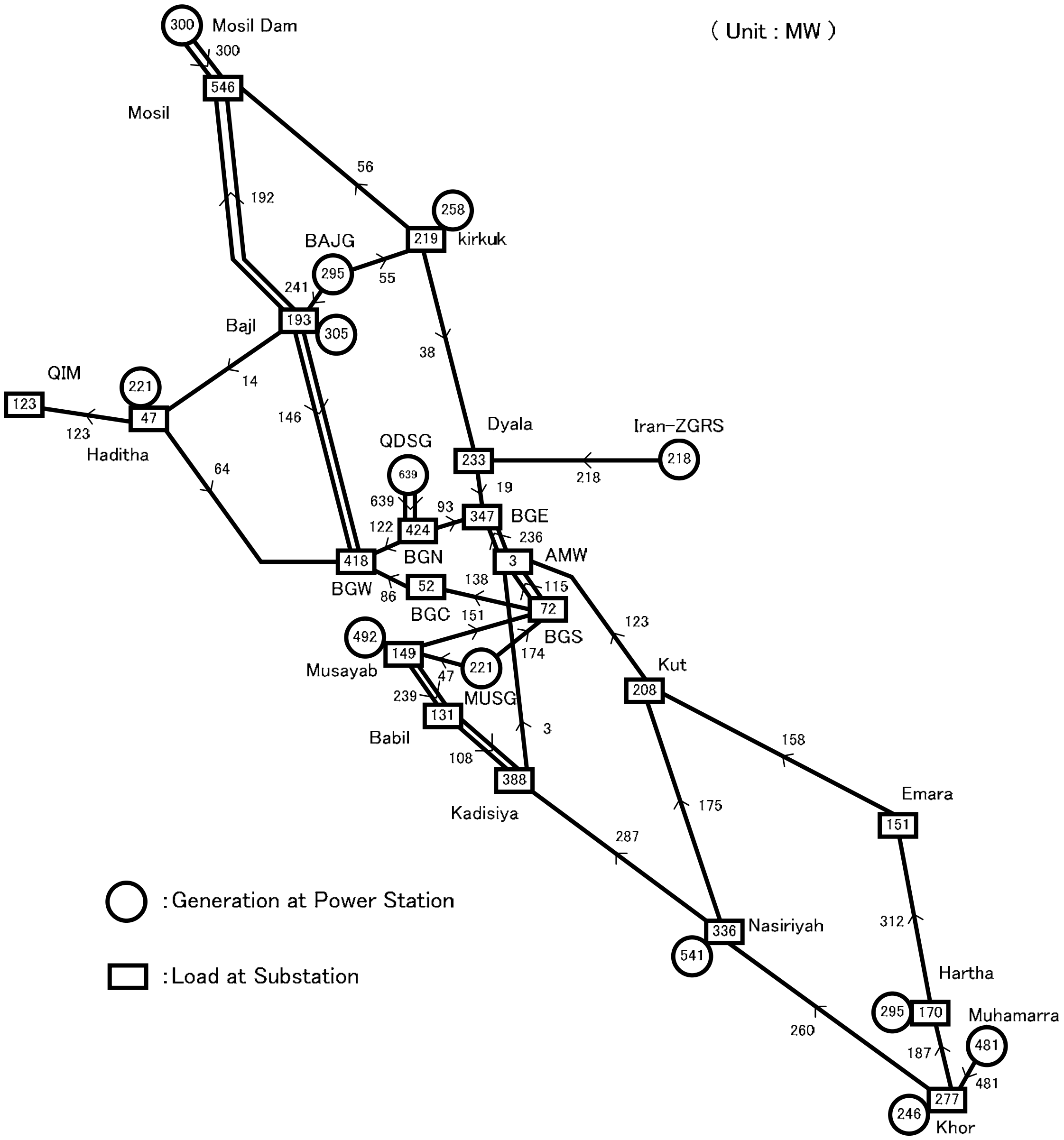
Source : MOE

(4) Power flow

Figure 2-2-9 shows power flow analysis results calculated based upon PSSE network data as of the year 2011 that was provided by MOE. As described in Chapter 2.2.2 (2), relatively large power flows are observed from Southern region, where many power plants are located, to Central region, where a load center, Baghdad, is located. On the contrary, only small power flows are observed in Northern, Eastern and Western regions since demand and supply are almost balanced in each regional power system. It's noted that Iraq imports 700MW from Iran through the international transmission line.

The maximum power flow is 481MW in Muhamarra-Khor line which figure is smaller than 950MW of the transmission line capacity.

In order to plan future networks, MOE applies N-1 criteria as described in its Grid Code as well as other countries. This is based on the concept that electricity should be supplied to customers, even if one unit in N units of facilities becomes outage due to fault occurrence. For transmission lines, in case that the circuit is suddenly opened after a fault occurs in one circuit, the problem like overload should be avoided in all other circuit, even if the power flow before the fault is bypassed to the other circuits.



Source : Network analysis result using PSSE data of MOE

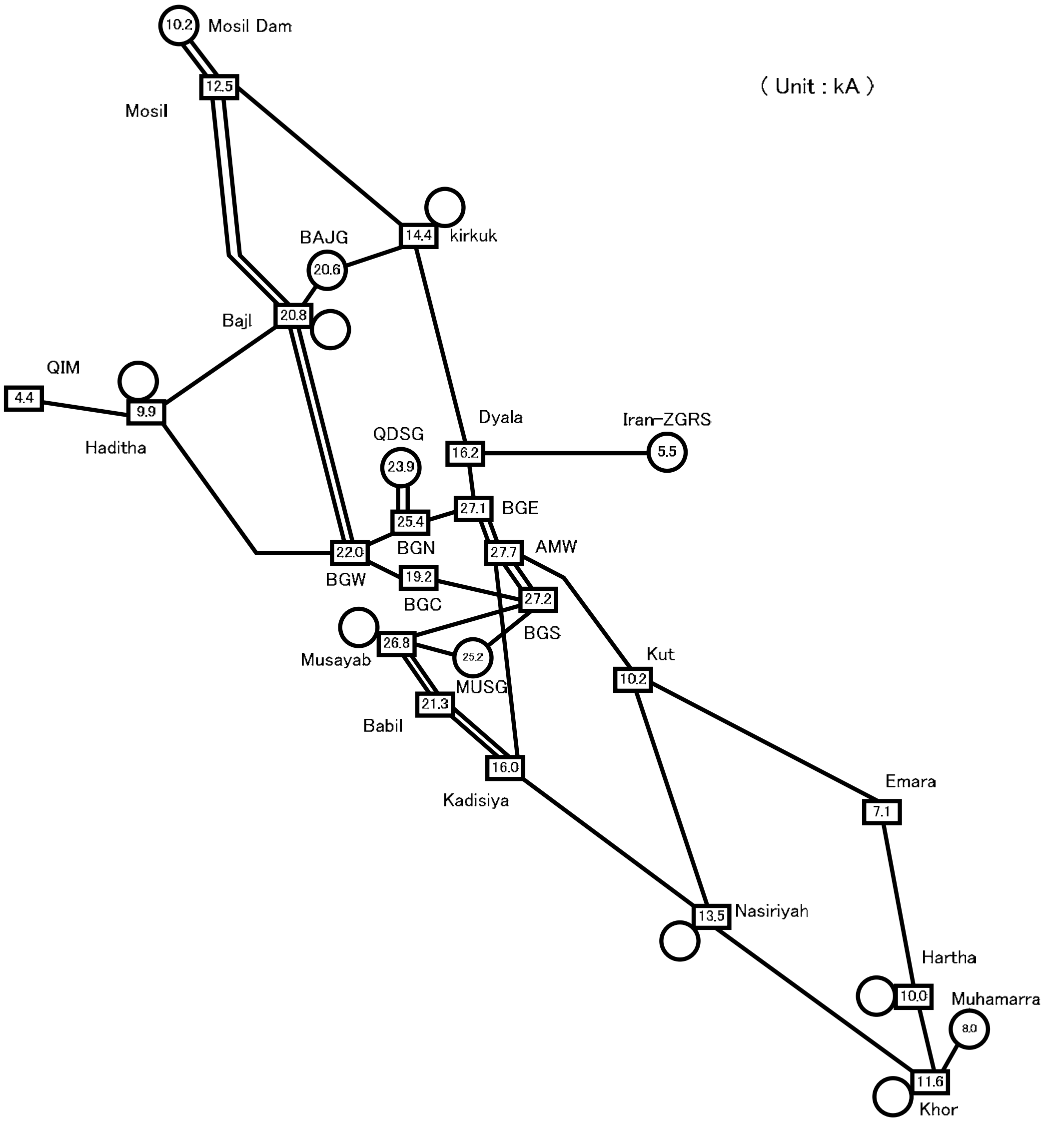
Figure 2-2-9 Power Flow of 400kV Network in 2011

(5) Fault current

Figure 2-2-10 shows the fault current analysis results. The maximum fault current in each region is as follows;

Baji in Northern region: 20.8kA, Kirkuk in Eastern region: 14.4kA, Amen in Central region: 27.7kA, Haditha in Western region: 9.9kA, Musayab in South-west region: 26.8kA and Nasiryah in Southern region: 13.5kA.

Since there are many power plants and substations, relatively large fault currents are observed in Central region and South-west region. However, those are less than the rated breaking current of circuit breakers 40kA or 31.5kA. Therefore, it is judged there is no problem at present.



Source : Network analysis result using PSSE data of MOE

Figure 2-2-10 Fault Current in 400kV Network in 2011

2.2.3 Electricity Tariff System

Averaged electricity selling price is hiked from 2.5 Iraqi dinar (0.21 UScent / kWh) to 27 Iraqi dinar (2.3 UScent / kWh) in 2008, and is planned to be raised up to 85 Iraqi dinar (7 UScent / kWh) in the future (2013) as shown in Table 2-2-6.

Table 2-2-6 Electricity Tariff System

	From 2008 to Dates		Proposal Tariff in the future (2013)	
Residential	**Band (kWh)**	**ID/kWh**	**Band (kWh)**	**ID/kWh**
	1 - 1000	10	1-600	10
	1001 - 2000	20	601-1200	25
	2001 - 4000	30	1201-2000	50
	4001 - more	50	2001-2500	60
			2501-3500	70
			3501-4500	80
			4501-6000	90
			6001-more	100
Commercial	**Band (kWh)**	**ID/kWh**	**Band (kWh)**	**ID/kWh**
	1 - 1000	10	1-300	10
	1001 - 2000	20	301-600	25
	2001 - 4000	30	601-900	50
	4001 - more	50	901-1200	60
			1201-3000	70
			3001-6000	80
			6001-more	100
Industrial	**Band (kWh)**	**ID/kWh**	**Band (kWh)**	**ID/kWh**
	1 - 1000	10	0.4kV	80
	1001 - 2000	20	11kV	70
	2001 - 4000	30	33kV	60
	4001 - more	50	132 kV	50
Governmental	**Band (kWh)**	**ID/kWh**	**Band (kWh)**	**ID/kWh**
	1 - 1000	10	1-500	20
	1001 - 2000	20	501-1000	40
	2001 - 4000	30	1001-2000	60
	4001 - more	50	2001-4000	80
			4001-more	100
Agricultural	**Band (kWh)**	**ID/kWh**	**Band (kWh)**	**ID/kWh**
	1 - 1000	10		50
	1001 - 2000	20		
	2001 - 4000	30		
	4001 - more	50		

Source : MOE

Chapter 3

Site Selection of Southern Thermal Power Project

Chapter 3 Site Selection of Southern Thermal Power Project

3.1 Site Selection of Likely Thermal Power Projects

3.1.1 Review of Pre-Feasibility Report

(1) Review procedure

Firstly the conditions of the sixteen (16) candidate sites identified by the Pre-Feasibility Study (Pre-FS) are reviewed. Although seventeen (17) sites were nominated in the Pre-FS, Shat Al-Basra 2 is excluded because it was decided to develop it as an IPP project. The Study Team collects related information in Japan as much as possible such as wide range geological map, Google-Earth topographical map, information on Ramsar site and proposed protection area in addition to the information obtained through the Pre-FS.

Secondly the Study Team evaluates comprehensively the sixteen (16) sites based on the evaluation criteria such as economical efficiency (available fuel type and cooling system), geology, hydrology and environmental considerations. The Study Team selects three likely candidate sites based on the above evaluation and decides finally the ones through the close consultation with the Counterparts.

(2) Ranking of candidate sites of Southern Large Scale Thermal Power Plant

At first, the Study Team excluded the sites which could not secure the necessary site area of 1,200MW thermal power plant, are located in wadi area and covered hidden lake deposited layer from the geological viewpoints, and are located within protected area and Ramsar site from environmental viewpoints. However, in practice there are no exclusions from the geological and environmental viewpoints, since the Study Team could not obtain conclusive information for making a decision regarding geological and environmental criteria. Accordingly, the Study Team noted the geological and environmental issues on each candidate site.

(a) Criteria of site area

The Study Team set up the site area criteria of more than 50 ha based on our past experiences taking into consideration the output of 1,200MW class, configuration of power system, cooling system facilities such as cooling tower and water treatment system for service water.[3]

(b) Geological criteria

The subsurface geology around the candidate sites located along the Tigris, Euphrates and Shatt Al-Arab River are assumed to be floodplain sediment which has been brought by floods from the upper basin. Despite the presence of floodplain sediment which covers the lower stratum, canals were built and land filled in the past in this area. Accordingly, unsuitable topographical and geological features such as the old stream and deposited layers in covered hidden lakes, which were locally formed by flooding, should be excluded as candidate sites for a bearing layer of thermal power plant.

(c) Environmental considerations criteria

The Ministry of Environment has been processing the application for approval to establish “Mesopotamian Marshlands National Park”, and the Government of Iraq registered “Hawizah Wetland” under the Ramsar Convention in 2008. Both areas are in the southern Iraq. It is critical to verify that the candidate sites for the large scale thermal power plant are not located in these

[3] As the results from the screening process in land area, the rejected sites have only 2 to 25ha that are not enough to situate even a 1,200MW class CCTPP.

protected areas to conserve natural and cultural heritages. Figure 3-1-1 shows the proposed World Heritage sites and the TPP candidate sites.

Figure 3-1-1 Proposed World Heritage Sites and 16 TPP candidate sites

(Blue pins are proposed WHSs. Green pins are the TPP candidate sites)

Regarding the IBAs, all IBAs are some distances from the 16 candidate sites as shown in Figure 3-1-2.

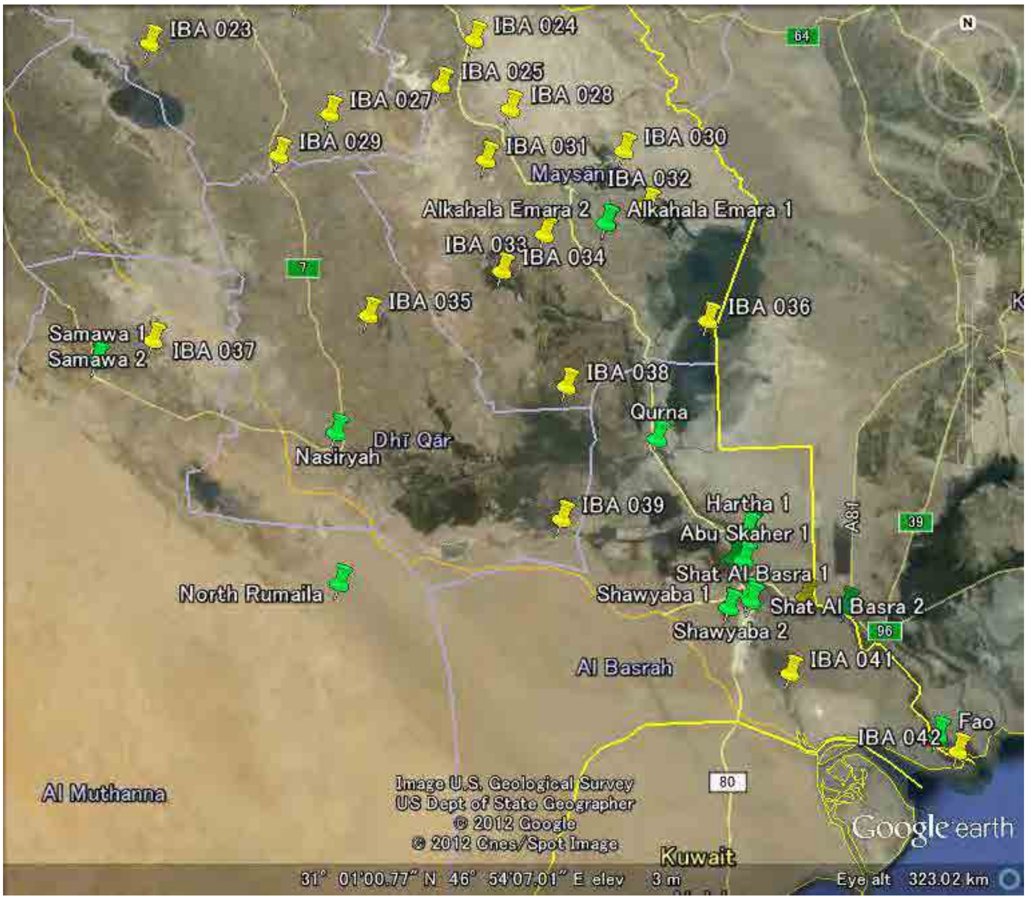


Figure 3-1-2 IBAs and 16 TPP candidate sites

(Yellow pins are IBAs and their numbers should be referred to Attachment -11. Green pins are the TPP candidate sites)

Secondly, the Study Team evaluated the rest of the sites from the viewpoints of economical efficiency such as fuel type, cooling system, civil design according to the geological condition, and environmental considerations. The Study Team ranked sixteen (16) candidate sites comprehensively based on the above-mentioned evaluation results.

(a) Fuel Type

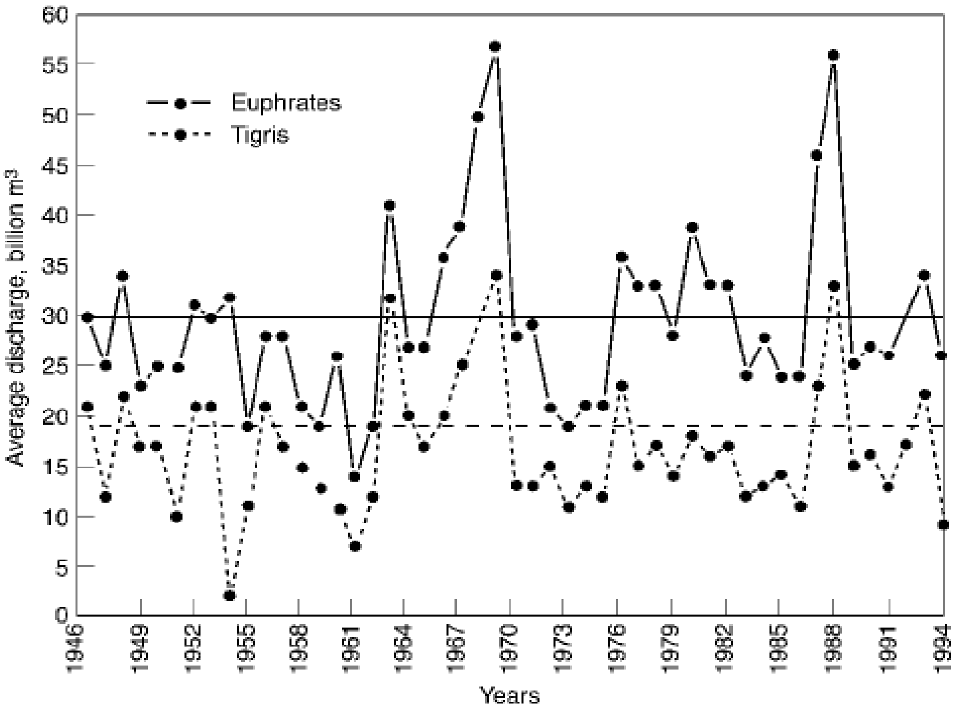
Since it is more beneficial to export crude oil out of the state rather than to use crude oil for power generation in general, candidate site where crude oil is the only available fuel was ranked low.

(b) Cooling system

Steam turbine condenser cooling is significant part of BOP (Balance of Plant). Either once-through cooling system or wet cooling tower system are commonly applied because of their economic viability when water resource is available for intake. Therefore, project sites adjacent to the large river such as Euphrates and Tigris should be advantageous in terms of cooling methods.

In the meantime, the JICA Study Team had understood that Euphrates and Tigris would have plenty of water flows sufficient to allocate for power generation projects. Figure 3-1-3 shows the record of annual flow rate in 1946 thru 1994. Even in the drought year, Euphrates and Tigris River retained around 20 billion m^3/year (630m^3/sec) and 10 billion m^3/year (315m^3/sec) respectively, while the once-through cooling system and the wet cooling tower system require around 30~40m^3/sec and

1m^3/sec water flow respectively assuming a 1,200MW CCTPP is installed. It seemed to be likely to apply either method. On the other hand, since some people concerned in Iraqi water resource sector paid attention on degradation of river flow, JICA Study Team identified necessity of further investigation on river water quantities.[4]



Source) Assessment of Surface Water & Groundwater Quality of Haur Al-Hammar after Restoration /Southern Iraq

Figure 3-1-3 Average Annual Discharges of Euphrates and Tigris Rivers

(c) Civil design according to geological condition

Most of the candidate sites are located in the vicinity of Euphrates, Tigris and Shatt Al-Arab River, and in the former marsh areas. However topographical and geological conditions can change significantly by a little away from rivers, lakes, and marshes. Therefore, the Study Team evaluated requirement of soil improvement for the foundation at each candidate site based upon the information of flooding risk and loose layer obtained from topographical and geological literatures. Figure 3-1-4 shows the distribution of Mesopotamian Marshlands in 1973 and 2000.

[4] As mentioned in Chapter 5, the JICA Study Team found that, under the recent river water condition, the once-through cooling system has been forbidden by Iraqi water resource authority. On the top of that, the JICA Study Team and MOE Team have agreed upon application of a design philosophy of "least water consumption and least waste water discharge" for the designing of power plant facilities, particularly cooling facility.

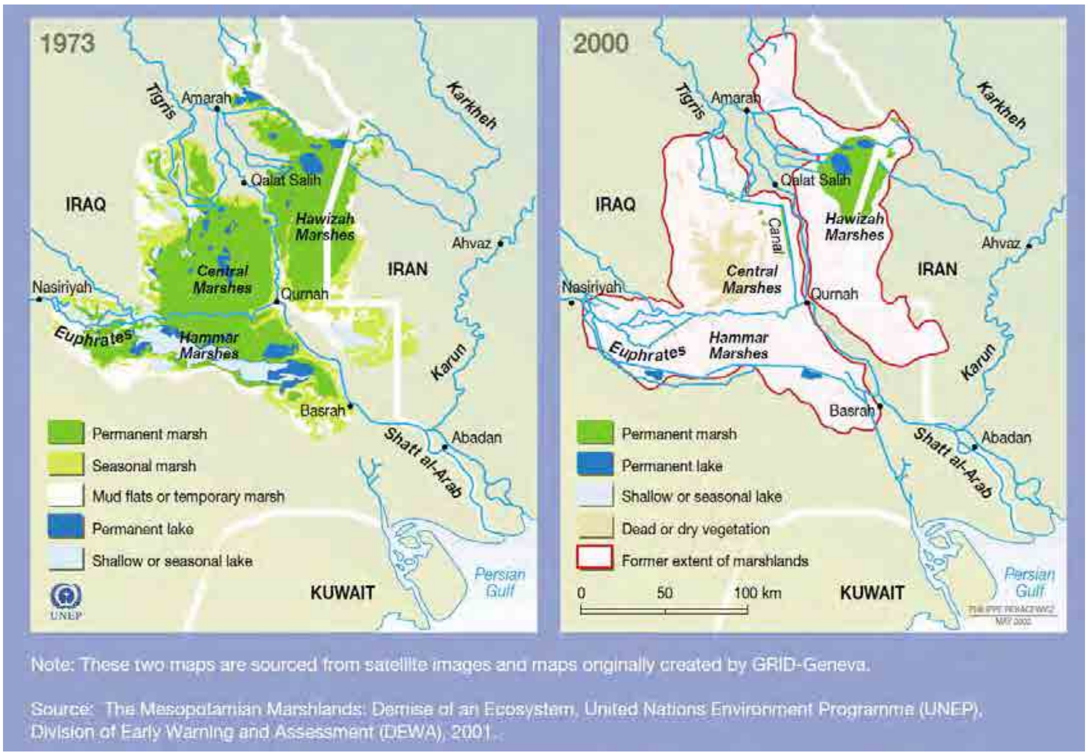


Figure 3-1-4　Mesopotamian Marshlands (1973 and 2000)

(d) Social environmental conditions

The study team evaluated the necessity of a large scale resettlement by confirming land use, land tenure and existing structures using the Google Earth satellite imagery.

3.1.2 Evaluation Results and Additional Site Reconnaissance

Among the 16 candidate sites, seven (7) sites were excluded because of too small site area. The rest of the sites, nine (9) sites, are evaluated from the viewpoints of economical efficiency such as distance from the river, available fuel type and geological conditions. The results are shown in Table 3-1-1. Alkahla Emara I & II, Hartha II, Nasiryah II sites are comprehensively ranked “A” which means there is no critical issues and more economical.

Accordingly, the Study Team selected three candidate sites such as Alkahla Emara I & II, Hartha II, Nasiryah II. Furthermore, the Study Team specified some issues on each sites as follows;

Alkahla Emara I & II sites:

- No specific issue

Hartha II site:

- The existing power plant which is located on the opposite bank of Hartha II site intakes cooling water of 28m3/sec

Nasiryah II site:

- There is no space for construction site on the same side (on the right bank of Euphrates River) of the existing power plant
- On the left bank of Euphrates River, there may be proposed national park
- The existing power plant intakes cooling water of 44m^3/sec.

Table 3-1-1 Evaluation Result (1/3)

No.		1	2	3	4	5	6
Name		Abu Skaher 1	Shat Al Basra 1	Shat Al Basra 2	Alkahala Emara 1	Alkahala Emara 2	Fao
Latitude North		30° 34' 41.1"	30° 26' 41.0"	30° 27' 36.6"	31° 41' 50.7"	31° 41' 53.1"	29° 58' 26.0"
Longitude East		47° 44' 13.9"	47° 45' 39.1"	47° 45' 11.0"	47° 15' 20.6"	47° 15' 30.4"	48° 27' 26.1"
Area		Basra	Basra	Basra	Mayssan	Mayssan	Basra
Map No.							
1/500,000 Geologic Quadrangle							
Land Area (by GPS)		50m x 500m (50m×500m)	500m x 500m (500m×500m)	1500m x 5000m (1500m×2000m)	4000m x 5000m (2000m×2000m)	4000m x 5000m (1000m×1500m)	1000m x 5000m (500m×1500m)
Accessibility	From main road	1.5 km	0.25 km	0.25 km	5 km	5 km	0.5 km
	Means	Road / River	Road / River	Road / River	Road	Road	Road
	Condition	Bad	Good	Good	Fair	Fair	Good
Topography		Flat, Gentle slope	Flat	Flat	Flat, Gentle slope	Flat, Gentle slope	Flat
Geology		Clay mix	Clay mix	Clay mix	Clay mix	Clay mix	Clay mix
Vegetation		Grass, Trees	N/A	N/A	N/A	Grass	N/A
Water resource	River name	Euphrates	Basra	Basra	Alkahala	Alkahala	Alarab
	From river (by GPS)	0.1 km	0.2 km	0.2 km	5 km (0.2km)	5 km (0.2km)	2km (1km)
	Width	400m	60m	60m	50m	50m	500m
	Depth	20-25 m	5-10 m	5-10 m	10 m	10 m	20 m
	From Pump Sta.	5 km	N/A	N/A	N/A (Water Gate 20km upstream)	N/A (Water Gate 20km upstream)	2km
Fuel	Fuel	Dry Gas	1) Kerosene, Gas Oil, HFO 2) Raw Gas / Dry Gas	1) Kerosene, Gas Oil, HFO 2) Raw Gas / Dry Gas	Raw Gas / Dry Gas	Raw Gas / Dry Gas	Crude Oil
	From fuel source	50 km	15km: 1) Basra Refinery 2) Gas Field	15km: 1) Basra Refinery 2) Gas Field	5 km: Halfya Oil Field Pipeline to Buzergan Located Next to Site	5 km: Halfya Oil Field Pipeline to Buzergan Located Next to Site	1 km: Transported through Crude Oil Tanks in the Port
	From fuel process	New Majnoon Gas Plant	Ditto	Ditto	Majnoon Gas Plant	Majnoon Gas Plant	N/A
	Note				Gas Oil Used Currently	Gas Oil Used Currently	
From 400kV sub-sta.		5 km	10 km	10 km	0.1 km	0.1 km	0.1km (132kV)
Enviroment observation	From protected area (including Ramsar Site)	Far	Far	Far	Far	Far	Far
	Fauna & flora	N/A	N/A	N/A	N/A	N/A	N/A
	World Heritage Site (including Proposed site)	Far	Far	Far	Far	Far	Far
	Resettlement (SAPROF Report and Google Map)	Yes	No	No	No	No	No
Primary Evaluation Criteria							
Land Area (by GPS)		Unsuitable (2.5ha)	Need careful layout (25ha)	No Problem (300ha)	No Problem (400ha)	No Problem (150ha)	No Problem (75ha)
Fuel type		Gas	Gas / Oil / HFO	Gas / Oil / HFO	Gas	Gas	Crude Oil
Cooling System (by GPS) A type : Once-through Cooling System B type : Cooling Tower system C type : Air Cooled Condenser System		Cooling system[1)] : A,B,C type Distance Intake-Site : No Problem	Cooling system[1)] : B,C type Distance Intake-Site : No Problem	Cooling system[1)] : B,C type Distance Intake-Site : No Problem	Cooling system[1)] : B,C type Distance Intake-Site : No Problem	Cooling system[1)] : B,C type Distance Intake-Site : No problem	Cooling system[1)] : A,B,C type Distance Intake-Site : No Problem
Civil design		Upper layer : Soil Improvement	Upper layer : Soil Improvement	Upper layer : Soil Improvement	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement
Geological condition		Risk attacked by flood Deep flood plain sediments South-eastern end of "Hawr al-Hammar" swampy area.	Expected on a natural levee Expected loose layer 1.9km downstream from Shat Al Basra 2 site	Expected on a natural levee Flood plain sediments. Expected loose layer	Flood plain sediments. Braided (inferred) original Tigris river to retarding basin "Umm An Ni aj".	Flood plain sediments. Similar condition as Alkahala Emara 1	Alluvial clay layer as a flood plain sediments Risk attacked by flood. Risk attacked loose and thick layer
Environmental condition		Many houses are observed around the site.	Nil	Nil	Nil	Nil	Nil
Primary Evaluation		C	C	A	A	A	B
Remark		Land area: Unsuitable Resselement:many houses Geological Risk	Land area: Unsuitable	IPP Project			Fuel: CO Geologocal Risk
Potential F/S site					○		

Table 3-1-1 Evaluation Result (2/3)

No.		7	8	9	10	11	12
Name		Qurna	Hartha 1	Hartha 2	Nasirya	North Rumaila	Sayba
Latitude North		30° 59' 09.2"	30° 40' 31.4"	30° 41' 03.1"	31° 02' 07.7"	30° 32' 30.3"	30° 24' 53.4"
Longitude East		47° 25' 22.7"	47° 45' 16.2"	47° 45' 47.1"	46° 11' 51.8"	46° 11' 51.8"	48° 07' 24.6"
Area		Basra	Basra	Basra	Thi Qar	Basra	Basra
Map No.							
1/500,000 Geologic Quadrangle							
Land Area (by GPS)		1000m x 2000m (500m × 1000m)	400m x 500m (200m × 200m)	2000m x 5000m (700m × 1500m)	500m x 1000m (Indefinite by fuzzy)	4000m x 5000m (7000m × 7000m)	4000m x 5000m (6000m × 7000m)
Accessibility	From main road	1.0 km	2.0 km	2.5 km	0.1 km	0.5 km	1.0 km
	Means	Road	Road / River	Road / River	Road	Road	Road
	Condition	Fair	Good	Fair	Good	Good	Good
Topography		Flat, Gentle slope	Flat	Flat	Flat	Flat	Flat
Geology		Clay mix	Clay mix	Clay mix	Clay mix	Desert / Sandy	Clay mix
Vegetation		Some Grass	N/A	Grass, Trees	N/A	N/A	N/A
Water resource	River name	Tigars	Euphrates	Euphrates	Euphrates	Euphrates	Shat Alarab
	From river (by GPS)	7 km (1.4km)	0.25 km	0.25 km	0.1 km	10 km	2 km
	Width	150m	500m	500m	100m	300m	500m
	Depth	20 m	20-25 m	20-25 m	20 m	15-20 m	20 m
	From Pump Sta.	5 km	5 km (nearby existing TPS Intake)	5 km (nearby existing TPS Intake)	0.1 km (nearby existing TPS Intake)	5 km	N/A
Fuel	Fuel	N/A	HFO	HFO	Dry Gas	Dry Gas	Dry Gas
	From fuel source	N/A	70 km: Basra Refinery	70 km: Basra Refinery	20 km: National Gas Pipeline	2 km: The Strategic Gas Pipeline Functioned	New Pipeline
	From fuel process	N/A	35 km	35 km	New West Qurna Gas Plant	South Gas Plant	New Majnoon Gas Plant
	Note		Crude Oil & Dry Gas Used Currently	Crude Oil & Dry Gas Used Currently	Crude Oil & FO Used Currently	SAPROF writes that liquid fuel will be used.	SAPROF writes that liquid fuel will be used.
From 400kV sub-sta.		0.1 km	N/A	N/A	0.1 km	7 km	N/A
Enviroment observation	From protected area (including Ramsar Site)	Nearby (Ransar Site)	Far	Far	Nearby (proposed National Park)	Far	Far
	Fauna & flora	N/A	N/A	N/A	N/A	N/A	N/A
	World Heritage Site (including Proposed site)	Far	Far	Far	Middle	Far	Far
	Resettlement (SAPROF Report and Google Map)	Yes	No	Yes	No	N/A	N/A
Primary Evaluation Criteria							
Land Area (by GPS)		No Problem (50ha)	Unsuitable (4ha)	No Problem (100ha)	No Problem (50ha)	No Problem (2000ha) [Extensible]	No Problem (2000ha) [Extensible]
Fuel type		N/A	Gas / Crude Oil / HFO	Gas / Crude Oil / HFO	Gas / Crude Oil / HFO	Gas / Crude Oil / HFO	Gas / Crude Oil / HFO
Cooling System (by GPS) A type : Once-through Cooling System B type : Cooling Tower system C type : Air Cooled Condenser System		Cooling system[1)] : B,C type Distance Intake - Site : No Problem	Cooling system[1)] : (A),B,C type Distance Intake - Site : No Problem	Cooling system[1)] : (A),B,C type Distance Intake - Site : No Problem	Cooling system[1)] : B,C type Distance Intake - Site : No Problem	Cooling system[1)] : A,B,C type Distance Intake - Site : Faraway	Cooling system[1)] : A,B,C type Distance Intake - Site : No Problem
Civil design		Upper layer : Soil Improvement	Upper layer : Soil Improvement	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : No need Soil Improvement	Upper layer : Soil Improvement
Geological condition		Flood plain sediments. Expected on a natural levee. Northern edge of "Hawr al-Hammar"swampy area. Seasonal marsh area Risk attacked by flood	Flood plain sediments. Seasonal marsh area Risk attacked by flood	Flood plain sediments. Expected on a natural levee.	Flood plain sandy sediments Expected on a natural levee.	On a hilly environment in the NE foot of the low hill trending to NW-SE. Very preferable, but no rivers for water supply are seen around the site.	Flood plain sediments. Expected loose and thick layer Risk attacked by flood
Environmental condition		SAPROF found that some houses needed to be resettled. Houses are observed between the site and the river, and it is necessary to confirm the situation by further survey.	Nil	SAPROF found that a school needed to be relocated. Houses are observed around the site, and it is necessary to confirm the situation by further survey.	The distance from the proposed National Park is not clear and it is necessary to confirm the boundary of the proposed National Park. A proposed WH site (Ur) is located at 17 km south-east of the Nasirya city.	There may be houses between the site and the river. Further survey is needed.	There may be houses between the site and the river. Further survey is needed.
Primary Evaluation		C	C	A	A	C	B
Remark		Fuel:N/A Nearby Ramsar site Geological Risk	Land area:Unsuitable Geological Risk		Land Area(Need careful Layout) Confirm Nearby proposed National Park	Intake system length	Intake system length Geological Risk
Potential F/S site				○	○		

Table 3-1-1 Evaluation Result (3/3)

No.		13	14	15	16	17	18
Name		Samawa 1	Samawa 2	Shawyaba 1	Shawyaba 2	Abu Skaher 2	
Latitude North		31° 17' 19.4"	31° 17' 15.1"	30° 25' 29.1"	30° 25' 33.7"	30° 34' 57.7"	
Longitude East		45° 16' 45.6"	45° 16' 31.1"	47° 40' 29.7"	47° 40' 25.7"	47° 41' 53.2"	
Area		Muthana	Muthana	Basra	Basra	Basra	
Map No.							
1/500,000 Geologic Quadrangle							
Land Area (by GPS)		500m x 1000m (250m×250m)	2000m x 4000m (450m×450m)	100m x 400m (100m×150m)	250m x 400m (100m×150m)	No Information (500m×1300m)	
Accessibility	From main road	2.0 km	2.0 km	11 km	11 km	1.5 km	
	Means	Road	Road	Road	Road	Road / River	
	Condition	Good	Good	Good	Good	Bad	
Topography		Flat	Flat	Flat	Flat	Flat, Gentle slope	
Geology		Clay mix	Clay mix	Sandy	Sandy	Clay mix	
Vegetation		N/A	N/A	N/A	N/A	Grass, Trees	
Water resource	River name	Alkadisia (branch Euphtates)	Alkadisia (branch Euphtates)	Shatt Albasra	Shatt Albasra	Euphrates	
	From river (by GPS)	3 km	3 km	1 km	1 km	0.1 km	
	Width	15-20 m	15-20 m	70m	70m	400m	
	Depth	10 m	10 m	15-20 m	15-20 m	20-25 m	
	From Pump Sta.	N/A	N/A	1 km	1 km	5 km (Nearby existing Intake)	
Fuel	Fuel	1) HFO: 50% + Crude Oil: 50% 2) Dry Gas	1) HFO: 50% + Crude Oil: 50% 2) Dry Gas	Dry Gas	Dry Gas	Dry Gas	
	From fuel source	5 km: Strategic Pipeline	5 km: Strategic Pipeline	3 km: New Pipeline	3 km: New Pipeline	50 km: New Pipeline	
	From fuel process	2) South Gas Plant	2) South Gas Plant	New Majnoon Gas Plant	New Majnoon Gas Plant	New Majnoon Gas Plant	
	Note						
From 400kV sub-sta.		0.1 km (132kV)	0.1 km (132kV)	0.1 km	0.1 km	5 km	
Enviroment observation	From protected area (including Ramsar Site)	Far	Far	Far	Far	Far	
	Fauna & flora	N/A	N/A	N/A	N/A	N/A	
	World Heritage Site (including Proposed site)	Far	Far	Far	Far	Far	
	Resettlement (SAPROF Report and Google Map)	N/A	N/A	Yes	Yes	N/A	
Primary Evaluation Criteria							
Land Area (by GPS)		Unsuitable (7ha)	Need careful layout (20ha)	Unsuitable (2ha)	Unsuitable (2ha)	No Problem (65ha)	
Fuel type		Gas / Crude Oil	Gas / Crude Oil	Gas	Gas	Gas	
Cooling System (by GPS) A type : Once-through Cooling System B type : Cooling Tower system C type : Air Cooled Condenser System		Cooling system[1] : B,C type Distance Intake - Site : No Problem	Cooling system[1] : B,C type Distance Intake - Site : No Problem	Cooling system[1] : B,C type Distance Intake - Site : No Problem	Cooling system[1] : B,C type Distance Intake - Site : No Problem	Cooling system[1] : A,B,C type Distance Intake - Site : No Problem	
Civil design		Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement (depend on detail Geo survey)	Upper layer : Soil Improvement	
Geological condition		Inferred preferable Expected on a spur of diluvial upland or natural levee	Almost similar condition as Samawa 1	Inferred preferable Expected on a diluvial upland or natural levee	Almost similar condition as Shawyaba 1	Flood plain sediments. Expected loose and thick layer South-eastern end of "Hawr al-Hammar" swampy area. Seasonal marsh area Risk attacked by flood	
Environmental condition		There may be houses between the site and the river. Further survey is needed.	There may be houses between the site and the river. Further survey is needed.	SAPROF found that some employees' houses inside the existing power plant site might have to be relocated. There may be houses between the site and the river. Further survey is needed.	SAPROF found that some employees' houses inside the existing power plant site might have to be relocated. There may be houses between the site and the river. Further survey is needed.	Information is limited.	
Primary Evaluation		C	C	C	C	B	
Remark		Land area: Unsuitable Intake system length	Land area: Unsuitable Intake system length	Land area: Unsuitable	Land area: Unsuitable	Geological Risk	
Potential F/S site							

3.2 Prioritization of Likely Thermal Power Project Sites

3.2.1 Summary of Evaluation Results of Three Likely Candidate Sites

The Study Team evaluated priority of the three candidate sites (Nasiryah II, Hartha II and Alkahla Emara TPP) based on the related information and data provided by MOE.[5]

The evaluation points are as follows. Firstly, rank was put on each Candidate Site by evaluation point; secondary, comprehensive rank was put on each Candidate Site.

- Cost efficiency (Soil improvement, Transmission line reinforcement, Additional pipeline length)
- Infrastructure conditions (National gas pipeline, Transportability, Land expropriation)
- Social and natural environment negative impact

The comprehensive rank of three likely candidate sites is shown in Table 3-2-1, their locations are shown in Figure 3-2-1 and the dry natural gas pipeline map is shown in Figure 3-2-2.

Detailed information and data of each candidate are described in the next Session 3.2.2.

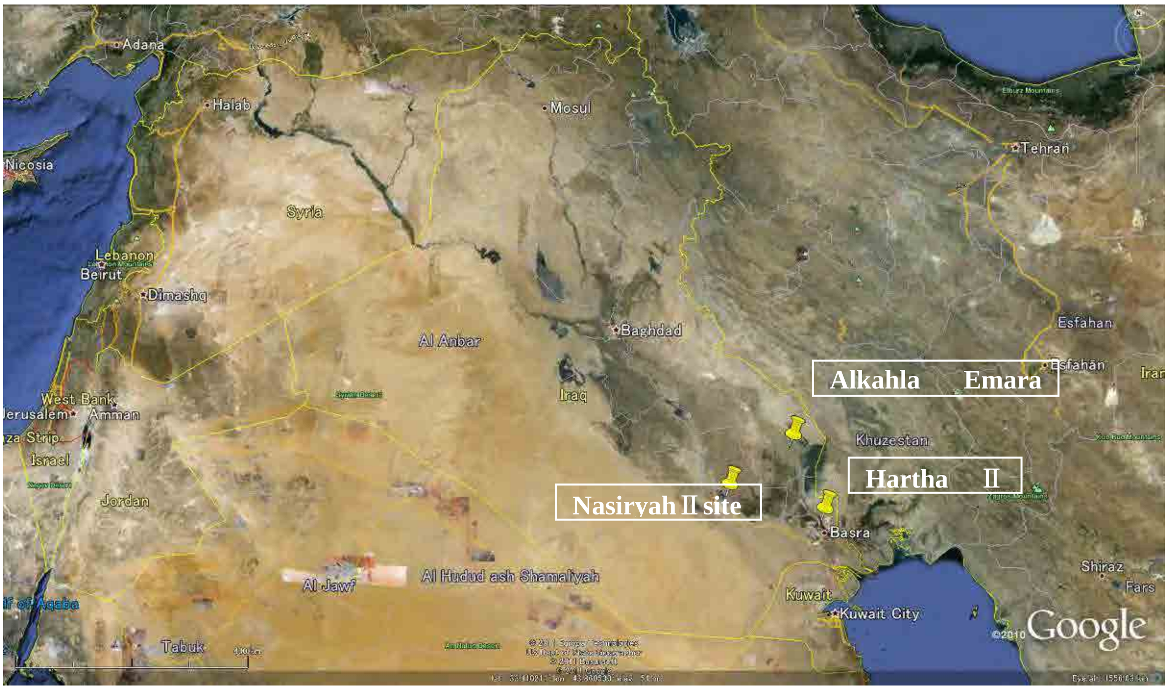
Table 3-2-1 Comprehensive Rank of Three Likely Candidate Sites for TPP Development

Evaluation Point		Nasiryah II TPP	Hartha II TPP	Alkahla Emara TPP
Location		Beside Existing TPP	Opposite bank of Existing TPP	Right bank of Alkahla River
Land Area		51ha	More than 100ha	More than 100ha
Economical Efficiency	Bearing Pile Length	Less than 30m	Around 30 m	Less than 30m
	Transmission Line Length Reinforced	Distance from Baghdad 337km	Distance from Baghdad 495km	Distance from Baghdad 361km
	Additional Pipe Line Length	10 km from National Gas Pipeline	Vicinity of Eastern Gas Pipeline	20 km from Eastern Gas Pipeline
Infrastructure Conditions	National Gas Pipeline	One is under construction and the other is planned to construct by 2014	Eastern gas pipeline is planned to construct by 2015	Eastern gas pipeline is planned to construct by 2015
	Transportability	Waterway, Railway and Road are available	Waterway, Road and Airport are available	Only road (one-lane road) is available
	Land Expropriation	Owner is MOE	Owner is local people	Owner is MOF, local people rent the land
Environment Impact	Resettlement	Nil	Involuntary resettlement is anticipated	Involuntary resettlement is anticipated (many bricks factories exist)
	National Park World Heritage	Out of National Park No heritage	Out of National Park No heritage	Out of National Park No heritage
	Endangered Species	Nil	Nil	Nil
Rank of Economical Efficiency		①	③	②
Rank of Infrastructure Conditions		①	②	③
Rank of Environment		①	②	③
Comprehensive Rank		①	②	③

[5] At the F/S stage, ACC Hybrid cooling was selected with respect to decreasing of river water flow. Because it also requires a certain amount of cooling water, the site selection procedure is still effective in consideration of distance from the river as one of the screening criteria

All likely candidate sites have no critical problems for development of TPP. Nasiryah II project site is ranked as the most priority site among three likely candidate sites, since especially infrastructure conditions (National gas pipeline, transportability and land expropriation) of Nasiryah II are in order. Therefore, Nasiryah II project site is recommended to select as a Feasibility Study site.

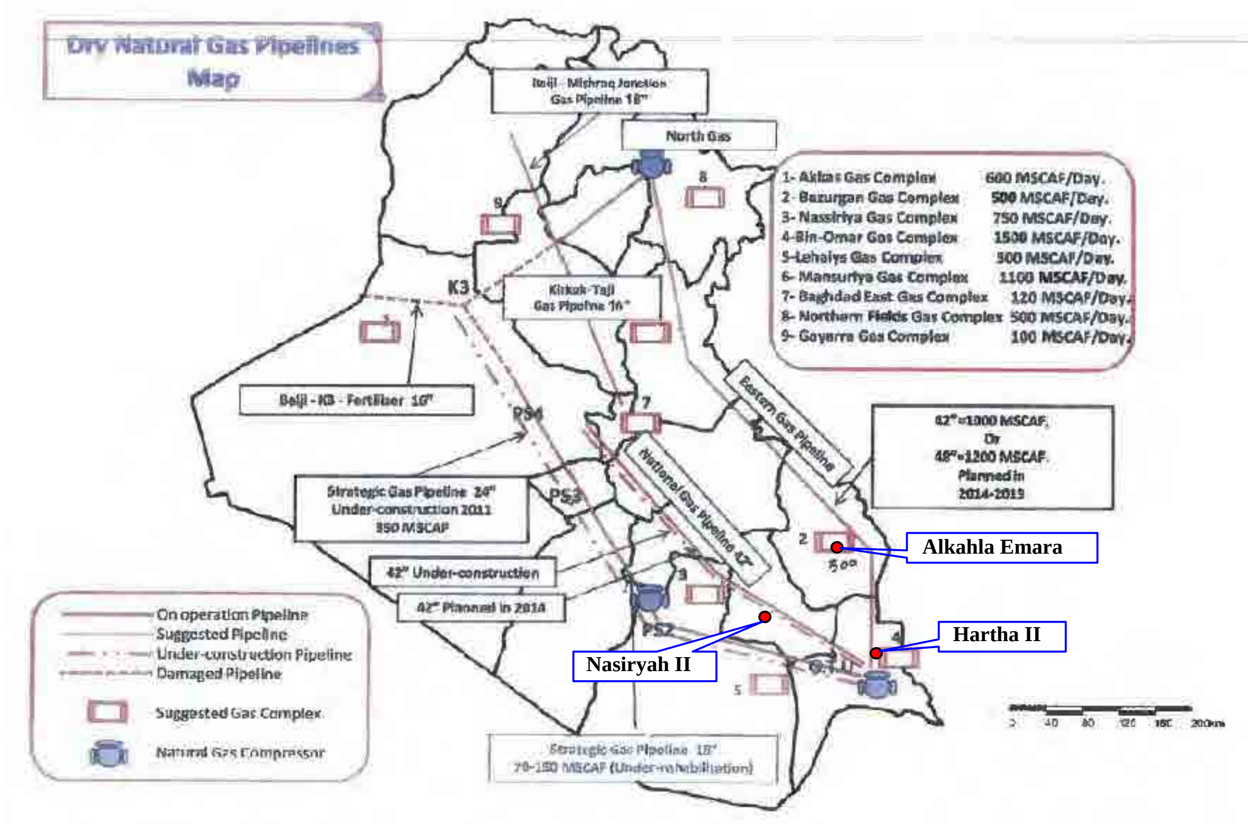
However, the shape of land area is narrow and long trapezoid, it is hard to layout efficiently the equipment and facilities including switchyard facilities. Accordingly, the Study Team will make wide range of topography map survey of 1/1000 and figure out whether or not the site area can be enlarged or be shifted to the east.



Source: Google Earth

Source: Google Earth

Figure 3-2-1 Location of 3 Likely Candidate Sites



Source: Master Plan Final Report (December 2010)

Figure 3-2-2 Dry Natural Gas Pipelines Map

3.2.2 Detailed Evaluation Results of Each Likely Candidate Sites

(1) Nasiryah II Project Site

Detailed information and data on evaluation items of Nasiryah II project site are summarized in Table 3-2-2. The project site area is shown in Figure 3-2-3 and Photo 3-2-1. And the geological map is shown in Attachment - 2.

Table 3-2-2 Detailed Information and Data of Nasiryah II Project Site

Site Name		**Nasiryah II Project Site**
A. Land Use	1. Location	- Northwestern edge of Nasiryah city on the right bank of Euphrates river - Close to the existing Nasiryah Power Station
	2. Near City	- Nasiryah City
	3. Land Area	- 51.29ha = [46.94ha + 4.35ha (new area: 30m*1450m)].
	4. Land owner 5. Land use status	- Ministry of electricity is the official owner of the project area which will be a part of the existing Nasiryah Power Plant
	6. Accessibility	- Baghdad – Basra highway, it is located 25 km far from the project area. - Basra - Al Nasiryah road way, two lane road. - Beside railway line (Baghdad – Basra).
	7. Land Constraints	- There are no constraints
B. Power Network	8. Transmission Line	- Very near to existing 400kV network
	9. Transmission distance to Baghdad	- The distance from the site to Baghdad is 337km - Since generated power subtracted local power supply will be transmitted to the demand center of Baghdad, the shorter transmission distance is, the less necessary network reinforcement cost is.
C. Natural Condition	10. Meteorological condition 1) Rainfall (2000-2010)	[Nasiryah station] - Maximum annual rainfall amount : 245.8mm (2006) - Minimum annual rainfall amount : 56.9mm (2009) - Mean maximum monthly rainfall amount : 105.7mm (Apr. 2002)
	2) Ambient temperature (1992-2008)	- Mean maximum monthly temperature : 40.2°C (Jul. 2000) - Mean minimum monthly temperature : 9.0°C (Jan. 1992)
	3) Relative humidity (1992-2008)	- Mean maximum monthly relative humidity : 81% (Dec. 1997) - Mean minimum monthly relative humidity : 19% (Jun. 2006, Jul. 2005, 2006 and 2008)
	4) Wind speed (1992-2008)	- Mean maximum monthly wind speed : 9.3m/s (N/NW Jul. 1992)
	5) Atmospheric pressure	- No Information
	11. Record of historical floods	- No floods for more than 30 years
	12. Record of historical earthquakes	- No record of historical earthquakes(2000-2010)
D. Topography / Geology	13. Topographic condition	- The site is located on the flat dry marsh deposits which are considered as an accumulative geomorphic unit represented essentially by fluvial deposits with intercalation of lacustrine and anthropogenic deposits.
	14. Geological condition	- Mesopotamian plain which mainly consists of the Neogene deposits is distributed around the site. The thickness of Neogene (the Holocene and the Pleistocene) deposits is estimated around 20m in total - referred to the Nasiryah quadrangle-. - They cover the Paleogene sedimentary rocks which can be a bearing layer.

	15. Geotechnical survey result	- Bearing layer : expected less than 30m (conjectured from the soil investigation report for Nasiryah GT PS and Geological map)
	16. Civil design	- Bearing pile length for heavy equipment facilities is less than 30m
E. Water Condition	17. River water availability	- The project area is beside the existing Nasiryah PS locating beside Euphrates river
F. Fuel Condition	18. Fuel condition	- Gas (18″) and oil pipeline is located in the southern side. - Strategic Gas pipeline (24″) is under construction by 2011 in the southern side. - National Gas pipeline (42″) is under construction and another pipeline (42″) is planned to construct by 2014 in the northern side.
G . Transportation Condition	19. Transportability 1) Water way	- The available ports exists in Al Basra governorate with about 161 km distance
	2) Rail way	- Railway (Baghdad – Basra) exists beside the site.
	3) Road way	- Baghdad – Basra highway, it is located 25 km far from the project area. - Basra - Al Nasiryah road way: Two lane road
H. Environmental Considerations [Natural / Social Environment]	20. Resettlement (houses, farmlands, cemetery etc)	- No involuntary resettlement (including compensation and expropriation of land) is anticipated.
	21. Natural Park (e.g. proposed National Park), World Heritages	- In southern Iraq, there are two protected areas (or proposed protected area) declared by the Ministry of Environment. The Project area is located at the outside of them. - Ur Proposed World Heritage site is located at 15 km from the Project area. - No local heritage exists in the Project area.
	22. Endangered species	- No endangered species occur In the Project area
	23. Socially vulnerable people (including water right and fisheries in river)	- There are no ethnic minorities in the area and its surroundings. - The existing power station currently uses the water. However, the information on the water right issue is not available. - It is not confirmed whether fisheries are active in the vicinity of the Project area.
	23. Industrial Site Applicability	- The Ministry of Electricity is the official owner of the Project area, and it will be part of the existing power station. The project area is available for any industrial or economical activities.

Figure 3-2-3 Nasiryah II project site (by Google Earth)

Photo 3-2-1 Nasiryah II project site

(2) Hartha II Project Site

Detailed information and data on evaluation items of Hartha II project site are summarized in Table 3-2-3. The project site area is shown in Figure 3-2-4 and Photo 3-2-2 and 3-2-3. And the geological map is shown in Attachment - 2.

Table 3-2-3 Detailed Information and Data of Hartha II Project Site

Site Name		**Hartha II Project Site**
A. Land Use	1. Location	- Northwestern of Al Basrah city on the left bank of Shat Al- Arab river - Opposite bank of the existing Al-Hartha Power station
	2. Near City	- Al-Basra city
	3. Land Area	- More than 100ha from Pre-FS report.
	4. Land owner	- Most of land owners are the Iraqi people who live in the project area.
	5. Land use status	- Most of the project area is empty land, there are small area of date palms and local seasonal crops near the Shat Al-Arab river bank
	6. Accessibility	- The project area has difficult transportation accessibility, the only way is one lane road. - Shat Al-Arab river can be used for transportation.
	7. Land Constraints	- There are some constraints due to the ownership of the land of the site.
B. Power network	8. Transmission Line	- Very near to existing 400kV network
	9. Transmission distance to Baghdad	- The distance from the site to Baghdad is 495km - Since generated power subtracted local power supply will be transmitted to the demand center of Baghdad, the shorter transmission distance is, the less necessary network reinforcement cost is.
C. Natural condition	10. Meteorological condition 1) Rainfall	[Basra station] - No information
	2) Ambient temperature	- No information
	3) Relative humidity	- No information
	4) Wind speed (1993-2008)	- Mean maximum monthly wind speed : 7.7m/s (NW Jul. 2006)
	5) Atmospheric pressure (1993-2007)	- Mean maximum monthly atmospheric pressure : 1023mb (Dec. 1994) - Mean minimum monthly atmospheric pressure : 996mb (Jul. 1994, 1995 and 2000)
	11. Record of historical floods	- No floods for more than 30 years
	12. Record of historical earthquakes	- No record of historical earthquake(2000-2010)
ography /	13. Topographic condition	- The site is located on the left bank of the Shat Al-Arab river on the Mesopomian plain. The site seems to be a natural levee from the Google earth image.

	14. Geological condition	- Mesopotamian plain which mainly consists of the Neogene sediments is distributed around the site. The Neogene sediments which lie on the Dibdibba Formation of the Paleogene rocks consist of the fluvial deposits, marine sediments, and marine-estuarine deposits. - They cover the Dibdibba Formation with unconformity structure, which can be a bearing layer. The thickness of the Neogene deposits is estimated at least 14-18m referred to the illustration in the report of the Al-Basrah quadrangle. However, according to the draft report issued by the "Working team" of Gas Turbine power plant project, the bearing layer should be set moreover 22m based on their surveyed maximum depth. .
	15. Geotechnical survey result	- Bearing layer : expected 30m or deeper (conjectured from the Geological map) - Surface layer : Marine - estuarine deposits
	16. Civil design	- Bearing pile length for heavy equipment facilities is estimated 30m or more. - Soil improvement for the surface layer will be needed (Marine - estuarine deposits)
E. Water Condition	17. River water availability	- The project area is beside Shat Al-Arab river
F. Fuel Condition	18. Fuel condition	- The project area is near many fuel sources. - National Gas pipeline (42″) is under construction and another pipeline (42″) is planned to construct by 2014 in the western side. - Eastern Gas pipeline (42″ or 48″) is planned to construct by 2015 in the vicinity of the site.
G . Transportation Condition	19. Transportability 1) Water way	- The available ports exists in Al Basrah governorate
	2) Rail way	- No railway is available
	3) Road way	- There are two bridges which can be used to reach Al Basrah from Baghdad, two lane roads. - Airport exists at 30km distance from the site.
H. Environmental Considerations [Natural / Social Environment]	20. Resettlement (houses, farmlands, cemetery etc)	- Involuntary resettlement (or compensation, expropriation of land) is anticipated.
	21. Natural Park (e.g. proposed National Park), World Heritages	- In southern Iraq, there are two protected areas (or proposed protected area) declared by the Ministry of Environment. The Project area is far from them. - No World Heritage (or proposed) Site exists in or near the Project area. - No local heritage exists in the Project area.
	22. Endangered species	- No endangered species occur in the Project area.
	23. Socially vulnerable people (including water right and fisheries in river)	- There are no ethnic minorities in the area and its surroundings. - The existing power station currently uses the water. The information on the water right issue is not available. - The river is small and it is unlikely that fisheries are active in the river but it is not confirmed.
	24. Industrial Site Applicability	- Most of the land is private properties of the local people, and basically they live in the land. - Most of the project area is not utilized as farmland or other purposes, but the local people grow date palm and local seasonal crops near the river bank.

Figure 3-2-4 Hartha II project site (by Google Earth)

Photo 3-2-2 Hartha II Project Site (upstream of the existing Hartha PS)

Photo 3-2-3 Hartha II Project Site (downstream of the existing Hartha PS)

(3) Alkahla Emara Project Site

Detailed information and data on evaluation items of Alkahla Emara project site are summarized in Table 3-2-4. The project site area is shown in Figure 3-2-5 and Photo 3-2-4. And the geological map is shown in Attachment - 2.

Table 3-2-4 Detailed Information and Data of Alkahla Emara Project Site

Site Name		**Alkahla Emara Project Site**
A. Land Use	1. Location	- South of Al Emara city, near the right bank of Alkahla river
	2. Near City	- Al-Emara city
	3. Land Area	- More than 100ha from Pre-FS report
	4. Land owner	- Most of land belongs to the Ministry of Finance, and the land is rented to the local people
	5. Land use status	- Most of the land is empty, there are small area of date palms and local seasonal crops. Many bricks factories are distributed in and around this area
	6. Accessibility	- Al Alkahla- Al Emara road way, one lane road. - Al Emara –Baghdad road way, two lane road.
	7. Land Constraints	-
B. Power network	8. Transmission Line	- Very near to existing 400kV network
	9. Transmission distance to Baghdad	- The distance from the site to Baghdad is 361km - Since generated power subtracted local power supply will be transmitted to the demand center of Baghdad, the shorter transmission distance is, the less necessary network reinforcement cost is.
C. Natural condition	10. Meteorological condition 1) Rainfall	[Al Gharbi station] - No information
	2) Ambient temperature (1994-2008)	- Mean maximum monthly temperature : 40.2°C (Jul. 2000) - Mean minimum monthly temperature : 8.7°C (Jan. 2008)
	3) Relative humidity (1994-2000)	- Mean maximum monthly relative humidity : 85% (Dec. 1997 and 2000) - Mean minimum monthly relative humidity : 16% (Jun. 1996, Jul 1996 and 1997, Aug. 1996)
	4) Wind speed (1994-2008)	- Mean maximum monthly wind speed : 9.6m/s (NW Jul. 1995)
	5) Atmospheric pressure (1994-2004)	- Mean maximum monthly atmospheric pressure : 1,023mb (Dec. 1994) - Mean minimum monthly atmospheric pressure : 996mb (Jul. 1995)
	11. Record of historical floods	- No floods
	12. Record of historical earthquakes	- Small scale earthquakes had occurred near border with Iran (2000-2010)
Topography / Geolog	13. Topographic condition	- The site is located in the southeastern part of the Mesopotamian plain which is characterized by deltaic flood plain and vast marshes. The area has fault terrain with very low relief at EL +5.0 to 6.0m on the topographic map of Emara

	14. Geological condition	- Mesopotamian plain which mainly consists of the Neogene sediments is distributed around the site. The Neogene sediments consists of the fluvial and lacustrine origin and partly aeolian. Marine estuarine deposits are also recognized. - Fluvial sediments, marine sediments, and marsh and lake sediments cover the Pleistocene sediments. Total thickness of these Neogene deposits is estimated around 20m referred to the illustration in the report of the Al-Emara quadrangle.
	15. Geotechnical survey result	- Bearing layer : less than 30m deep (conjectured from the Geological map)
	16. Civil design	- Bearing pile length for heavy equipment facilities is less than 30m
E. Water Condition	17. River water availability	- The project area is beside Al Kahla river
F. Fuel Conditi on	18. Fuel condition	- Eastern Gas pipeline (42″ or 48″) is planned to construct by 2015 in the western side.
G .Transportat ion Condition	19. Transportability 1) Water way	- Although there is the Al Kahla river near the site, it is a small river.
	2) Rail way	- No railway is available.
	3) Road way	- Al Emara – Al kahla, one lane road
H. Environmental Considerations [Natural / Social Environment]	20. Resettlement (houses, farmlands, cemetery etc)	- Involuntary resettlement (or compensation, expropriation of land) is anticipated.
	21. Natural Park (e.g. proposed National Park), World Heritages	- In southern Iraq, there are two protected areas (or proposed protected area) decelerated by Ministry of Environment. The Project area is far from them. - No World Heritage (or proposed) Site exists in or near the Project area. - No local heritage exists in the Project area.
	22. Endangered species	- No endangered species occur in the Project area.
	23. Socially vulnerable people (including water right and fisheries in river)	- There are no ethnic minorities in the area and its surroundings. - The information on the water right issue is not available. - It is not confirmed whether fisheries are active in the vicinity of the Project area.
	24. Industrial Site Applicability	- Most of the land in this area belong to the Ministry of Finance, and are rented to local people. - Most of the land is not utilized but, in some part of it, the local people grow date palms and local seasonal crops. Many brick factories exist in the area.

Figure 3-2-5 Alkahla Emara project site (by Google Earth)

Photo 3-2-4 Alkahla Emara Project Site

Chapter 4

Optimization of the TPP Development Plan

Chapter 4 Optimization of the TPP Development Plan

4.1 Basic concept

In Iraq, the power shortage has been chronic after the war tone era. The Iraqi Government has a policy objective to cope with the electricity crises as the top priority. Therefore, early developments of larger and more efficient TPPs are envisaged to eliminate the chronic power shortage.

During the discussions with the JICA Study Team, MOE clearly mentioned its desires in terms of technical specifications of the envisaged Nasiryah II TPP as follows;

- Power generation capacity is set at 1,800MW in stead of 1,200MW in order to resolve the power shortage issue as early as possible.
- More highly efficient types of TPP are preferable to catch up the Government's target of upgrading the thermal efficiency as a whole.
- Provided that CCTPP is applied to Nasiryah II, the 300MW class GT is selectable at most in consideration of Iraqi operators' skills for operation and maintenance of GT so far.

Based upon the above mentioned conditions, the Study Team has materialized Nasiryah II TPP development plan thru the following process.

- First, fuel type, generation type, and unit capacity are selected thru the comparative studies in terms of economic efficiency, supply reliability, and environmental impact.
- Second, power block configuration is selected thru the comprehensively comparative study in terms of EPC cost, grid compatibility, operability, maintenance, reliability, etc.
- Third, power flow from Nasiryah II TPP is assessed in terms of stability of 400kV transmission network.

4.2 Fuel Type, Generation Type and Unit Capacity

4.2.1 Economic Comparison among Various Type of TPP

(1) Alternatives

Table 4-2-1 shows three alternatives for a new 1,800 MW power plant. These were comparatively studied in terms of economic efficiency, supply reliability, and environmental impact. It must be noted that all the costs in this chapter were calculated assuming the power plants were developed in USA where CCTPP's cost data is abundantly disclosed to its industrial market. Therefore, such calculated costs must be used for the comparative study only but not applicable for cost estimation of any projects in Iraq.

Table 4-2-1 Three alternatives for a new 1,800 MW power plant

	Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
Output	1,800MW	1,800MW	1,800MW
	900MW x 2	300MW x 6	600MW x 3
Fuel	Natural gas	Natural gas	Residual oil

The following assumptions are applied for determination of each unit capacity.

- The unit capacity of gas turbines is set at 300MW as the largest one in the gas turbine products available at present.
- 2-on-1 multi shaft configuration is assumed for the calculation of the "Combined Cycle (CC)" option. The capacity of a train of CC is set at 900MW.
- The capacity of steam turbine unit is assumed to be 600MW as commonly-used output for

commercial thermal power generation.

(2) Specifications of alternatives

Table 4-2-2 illustrates general specifications of generating type alternatives.

Table 4-2-2 General specifications of generating type

		Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
Output		1,800MW	1,800MW	1,800MW
		900MW x 2	300MW x 6	600MW x 3
Minimum output		450MW (50% of 1 train)	150MW (50% of 1 GTG)	180MW (30% of 1 unit)
Fuel		Natural gas	Natural gas	Residual oil
Fuel cost (USD/mmBTU)		5	5	16
Construction cost (USD/kW)		742	561	894
O&M cost	Fixed (USD/kW/year)	14.6	43.8	51.2
	Variable (USD/MWh)	3.11	12.4	3.51
Life (years)		25	25	25
Efficiency at rated net output (%)		57.3	38.7	41.0
Forced outage rate (%)		6	33	6
Scheduled outage (days/year/unit)		21	12	34

Note: All the costs were calculated on the basis of CCTPP industrial market in USA.

Assumptions applied are below.

(a) Fuel Cost

US Energy Information Administration published Annual Energy Outlook 2010 that stated natural gas price and residual fuel oil price in 2015 as per the below figures.

Natural gas	5.54 USD/Million BTU	
Residual fuel oil	97.61 USD/bbl	
	15.8 USD/Million BTU	(assuming 41MJ/litre)

The residual fuel oil is assumed to be of low sulfur content (less than 1%) and priced on the FOB power plant basis in USA including freight charge to power plant.

(b) Construction Cost

The CCTPP construction cost is roughly estimated by GT-Pro assuming the power plant is located in USA. The construction costs for simple GT and simple ST are respectively estimated in consideration of the cost for complete CCTPP and the construction factors illustrated in the authorized report[6].

[6] Technical and Economic Assessment of Grid, Mini-Grid and Off-Grade Electrification Technologies, The World Bank Group Energy Unit, Energy, Transport and Water Department, September 2006.

(c) Annual O&M Cost

All figures of annual O&M cost are derived from the report[7].

(d) Efficiency

Thermal efficiency of each type is calculated by GT-Pro. As for ST plant, the typical thermal efficiency of a 600MW class plant is applied.

(e) Forced Outage Rate (FOR)

Typical figures of FOR are cited from NERC Generating Availability Report 2006 - 2010 Annual Unit Performance Statistics. In USA, a simple cycle GT has the higher FOR compared to other types. Because it is obliged to undertake frequent start-and-stop operations as a peaking power supply source, its FOR could be higher under such severe operational condition.

It is however supposed that FOR could be same between simple cycle GT and CCTPP in Iraq. Because simple cycle GT could be operated continuously at its full capacity in Iraq.

(f) Scheduled Outage

All figures of scheduled outage are derived from NERC Generating Availability Report 2006 - 2010 Annual Unit Performance Statistics.

(3) Generating cost

Assuming the annual plant factor is 80%, the power generating cost of each type is shown as Table 4-2-3.

Table 4-2-3 Generating Cost

(Unit: Cent/kWh)

		Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
Fixed	Capital	1.2	0.9	1.3
	O&M cost	0.2	0.6	0.7
Variable	O&M cost	0.3	1.2	0.4
	Fuel	3.0	4.4	13.3
Total		4.7	7.2	15.7

In the comparative study, CCTPP is more advantageous in generating cost. Oil-fired ST power plant has a disadvantage in cost because of high oil price. However, this might be incorrect because this calculation was made based on US market condition such as a FOB-power-plant based oil price. In the PB made PDP in December 2010, the oil price in Iraq is supposed to be 35% of the above-mentioned US oil price in case that a power plant can use high sulfur heavy oils containing 3% or more sulfur contents which supplied from oil refineries nearby. In this regard, fuel cost for ST is regarded as 4.7 Cent/kWh so that generating cost comes down from 8.6Cent/kWh to 7.1Cent/kWh. This is almost identical generating cost level as GT type. It is noted that a desulfurizer or scrubber is needed if using high sulfur oil causing a increase in the fixed cost.

Figure 4-2-1 shows numerical relation between availability factor and generating cost. CCTPP is the most advantageous through every availability factor area.

[7] Technical and Economic Assessment of Grid, Mini-Grid and Off-Grade Electrification Technologies, The World Bank Group Energy Unit, Energy, Transport and Water Department, September 2006.

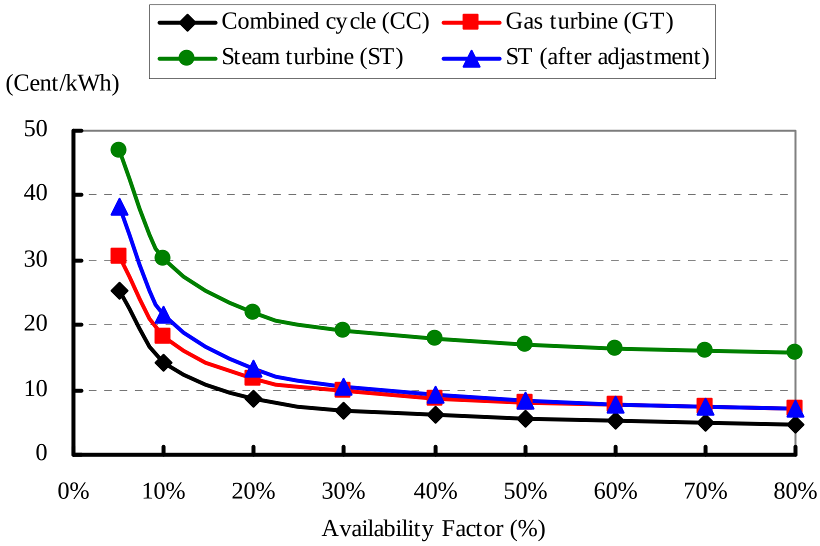


Figure 4-2-1 Relation between Availability Factor and Generating Cost

(4) Supply reliability

Table 4-2-4 shows forced outage rate and scheduled outage of each generation type. The total output of each generation type was lined up at 1,800MW so as to precisely compare reliability of each generating type.

Table 4-2-4 Forced Outage Rate and Scheduled Outage

	Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
	900MW x 2	300MW x 6	600MW x 3
Forced outage rate (%)	6	33	6
Scheduled outage (days/year/unit)	21	12	34

Table 4-2-5 shows Loss of Load Expectation (LOLE) representing level of power supply reliability of each generation type. In 2020, the installed capacity of Iraqi power system would be approximately 22,000MW, of which 1,800MW is assumed to be replaced by the proposed power plants for this calculation. The calculated LOLE for each type of generation is shown in Table 4-2-5. In case of GT, FOR=33% and 6% are both applied in consideration of empirical relation between plant factor and FOR as mentioned above.

Table 4-2-5 LOLE Value

	Combined cycle (CC)	Gas turbine(GT)		Steam turbine (ST)
		FOR = 33%	FOR = 6%	
LOLE Value (hours/year)	18.7	51.7	12.3	18.5

The levels of the supply reliability are almost identical between CCPTT and ST. Both CCTPP and ST have the same figure of the forced outage rate (6%). Meanwhile, ST requires longer annual maintenance period than CCTPP. CCTPP has a disadvantage assuming the significant impact onto the power system stability when it does stop operation because its unit capacity is generally larger than ST's unit capacity.

(5) Environmental impact (CO_2 emission)

Table 4-2-6 shows the calculated CO_2 emissions in a 1,800MW development case assuming the plant factor is 80%. As a result, CCTPP has the lowest CO_2 emission.

Table 4-2-6 CO_2 Emission

	Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
	900MW x 2	300MW x 6	600MW x 3
Fuel	Natural gas	Natural gas	Residual oil
CO_2 emission (million kg-CO_2)	4,447	6,584	8,124
Unit CO_2 emission (kg-CO_2/kWh)	0.35	0.52	0.64

(6) Comprehensive evaluation

Table 4-2-7 shows comprehensive evaluation. CCTPP is overwhelmingly advantageous in every criterion. In conclusion, CCTPP should be selected for further studies.

Table 4-2-7 Comprehensive Evaluation

	Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
Economic efficiency	◎	△	×
Supply reliability	○	△	○
Environmental impact	◎	△	△
Comprehensive evaluation	◎	△	△

Note: ◎=much advantageous, ○=advantageous, △=intermediate, ×=disadvantageous

4.2.2 Economic Comparison among Various Type of Combined Cycle Power Plant

(1) Alternatives

Base on the result from the comparative study on generation type, it is ascertained that a CCTPP power generating plant is advantageous. This chapter illustrates another comparative study on CCTPP plant configuration such as Single shaft 1-on-1, Multi shaft 1-on-1, and Multi shaft 2-on-1 shown in Table 4-2-8 and Figure 4-2-2.

Table 4-2-8 Configuration of Combined Cycle Plant Type

	Type A	Type B	Type C
Configuration	Single shaft type 1GT＋1ST	Multi shafts type 1-on-1 1GT＋1ST	Multi shafts type 2-on-1 2GT＋1ST

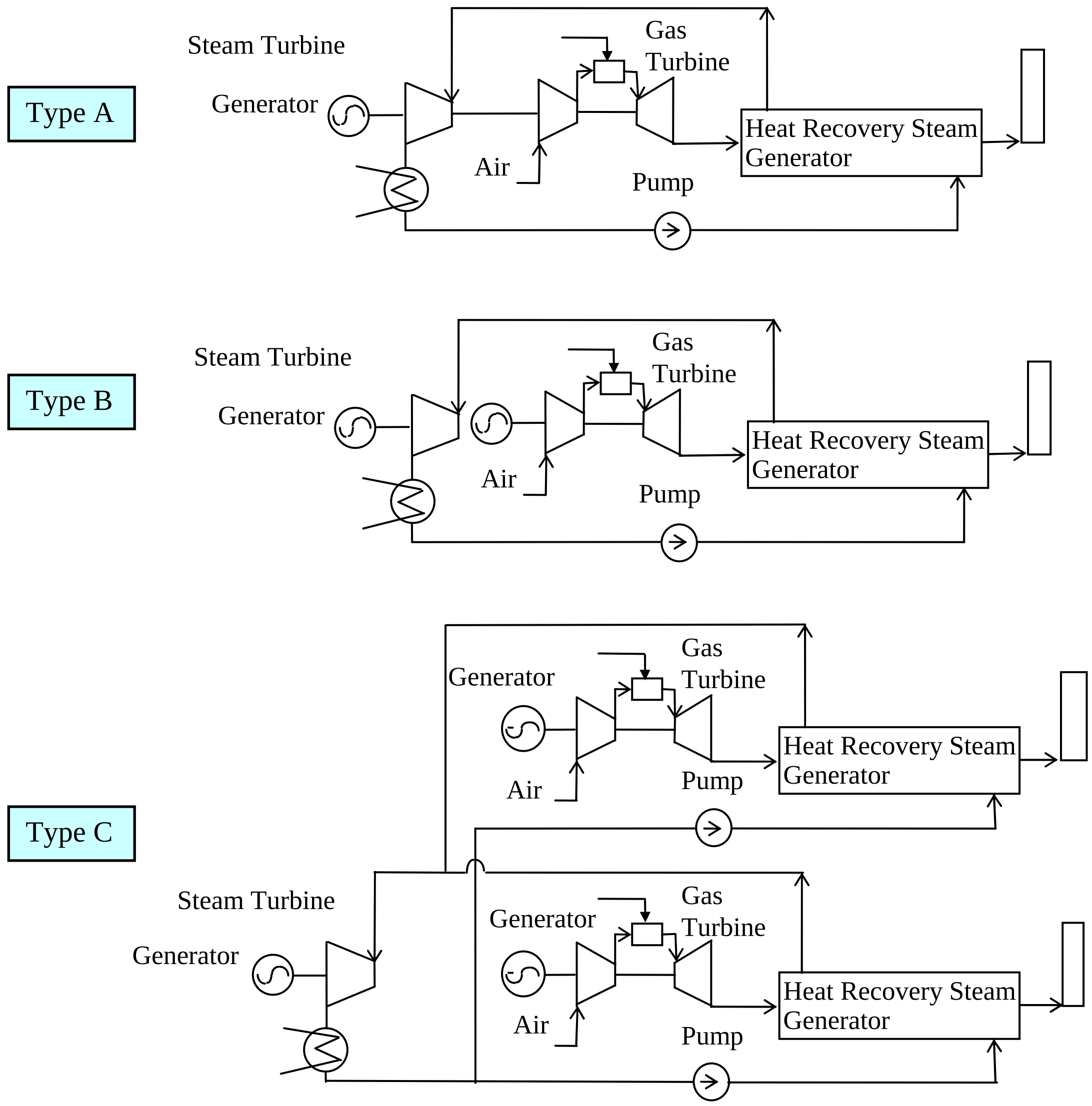


Figure 4-2-2 Configuration of each Type

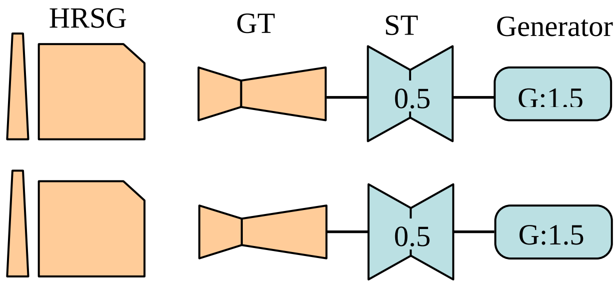
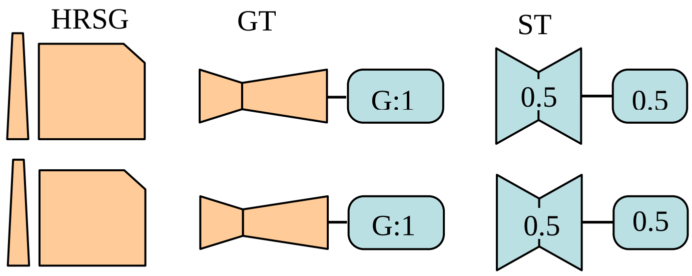
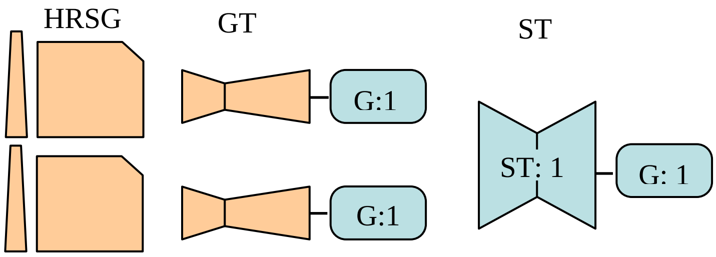
(2) Conceptual comparison of CCTPP configuration

(a) Construction Cost

Construction cost of each case is estimated under the identical condition assuming;

- 2 sets of GTs are applied for each configuration,
- Construction cost is proportionate to the 0.6 power of physical scale of plant,
- Common facility such as HRSG and GTs are same value among every configuration,
- Cost of ST generator is regarded as 1, of which 0.3 is for generator and 0.7 is for steam turbine.

Table 4-2-9 Construction cost of CCTPP

	Configuration	Cost for G and ST
Single shaft (Type A)		ST = 0.66 x 0.7 x 2 GT = 1.28 x 0.3 x 2 Total = 1.69
Multi shaft 1-on-1 (Type B)		ST = 0.66 x 0.7 x 2 GT = (1+0.66) x 0.3 x 2 Total = 1.92
Multi shaft 2-on-1 (Type C)		ST = 0.7 GT = 3 x 0.3 Total = 1.6

Type C has one steam turbine. Because it can optimize and maximize the scale of steam turbine, Type C is the lowest in unit construction cost (USD/kW). Meanwhile, Type A can have only two generators so that its construction cost does not greatly differ from Type C cost.

(b) Needs and limits of power output

As the power output of GT is set out stepwise in the maker catalogs, power utilities need to select the output capacity and configuration of CCTPP with respect to their requirements. The power output specification of GT is designed and configured by each manufacture as a default value that can not be adjusted in accordance with the user's requirements.

Table 4-2-10 shows default output of each CCTPP configuration. A train of Type C consists of two GTs and one ST, so-called 2-on-1 configuration. Therefore, the scale must be larger than other types. 2-on-1 configuration can only provide 900MW stepwise so that power output options are limited compared to other configurations patterns.

Table 4-2-10 Stepwise output of each configuration

	Number of GT unit			
	1 unit	2 units	3 units	4 units
Type A	450 MW	900 MW	1,350MW	1,800MW
Type B	450 MW	900 MW	1,350MW	1,800MW
Type C	N/A	900 MW	N/A	1,800MW

(c) Needs and Applicability of Simple Cycle

The multi shaft CCTPP such as Type B and Type C is able to operate as a simple cycle GT by optionally adopting bypass-dumper and bypass-stack. The required construction period for the simple cycle GT unit is 1 year shorter than the entire construction period of CCTPP plant. Therefore, provided that CCTPP is expected to start operation as soon as possible for meeting increasing power demand, it would better to complete the construction work for simple cycle GT unit first, and try to commence its commercial operation prior to completion of entire CCTPP construction works. This can bring a year's worth of economic benefit by relieving power shortage to Iraqi industry.

The additional cost for bypass-dumper and bypass-stack is estimated to be approximately USD 5 million in total on the USA basis. In addition, the simple cycle GT operation basically has lower thermal efficiency. If there is no urgent need, it would be better not to install such exhaust bypass equipment and to avoid simple cycle GT operation from the general viewpoint of economic efficiency.

In case of multi shaft CCTPP, Figure 4-2-3 shows a year's worth of economic benefit generated by a GT unit being operated as simple cycle 1 year prior to completion of the ST unit. This benefit can be correctly estimated by considering both the shortage cost and fuel cost reduction in entire Iraqi power system. The shortage cost accounts for incremental national benefit (GDP) generated by avoiding power shortage. In this study, 3 USD/kWh in 2010 basis is used as shortage cost that derived from the BP made power M/P.

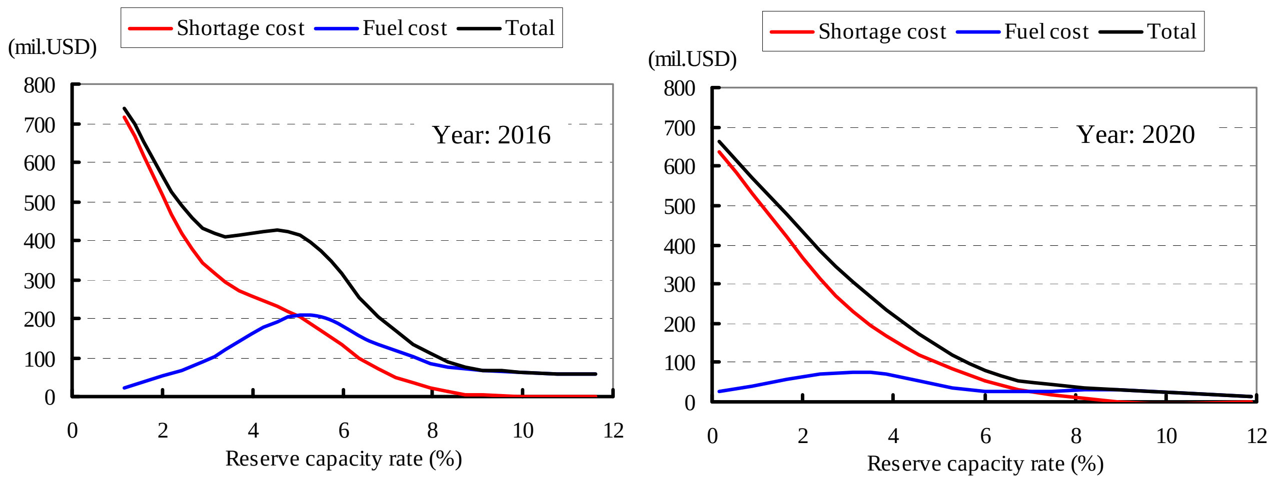


Figure 4-2-3 Economical Benefit of the preceding construction of GT (1 Unit)

1) Benefit from power shortage avoidance (equivalent to shortage cost)

Shortage cost is subject to the amount of reserve capacity in the power system at the timing of simple cycle GT installation. Provided that Iraqi power system is well developed as scheduled in the power M/P, the expected reserve margin is 12% so that additional simple cycle GT could not generate any benefit equivalent to shortage cost. However, assuming the reserve margin is less 5%

due to the delay of power development schedule, shortage cost could be estimated to be more than USD100 million. In this regard, prior commencement of simple cycle GT operation could become economically feasible.

2) Benefit from fuel cost reduction

Fuel cost reduction is much dependent on the composition of power generating types and the reserve capacity in Iraqi power system at the timing of simple cycle GT installation. In 2017 (the target year of simple cycle GT installation), comparatively expensive HSD and crude oil are still used for power generation, and therefore simple cycle GT has advantage in generating cost if it is fueled by low priced natural gas. In addition to that, thermal efficiency of simple cycle GT is expected to be 38% or more in comparison with the average thermal efficiency 32% in the Iraqi system in 2017. In conclusion, a USD40 million fuel cost reduction is expected at least regardless of the status of reserve capacity.

In 2020, it is supposed that consumption of HSD and crude oil could be decreased and the average thermal efficiency in entire Iraqi system could be improved by 40%. Fuel cost reduction by simple cycle GT is less expected thereby.

3) Overall evaluation

In 2017, prior commissioning of simple cycle GT is quite advantageous from the viewpoint of reducing overall power generating cost in Iraqi power system. This benefit could be generated by reducing fuel cost. If Iraqi MOE thinks that eliminating short-term power shortage is more important, selecting multi shaft CCTPP configuration and starting its operation along with simple cycle GT prior to CCTPP operation are more advantageous.

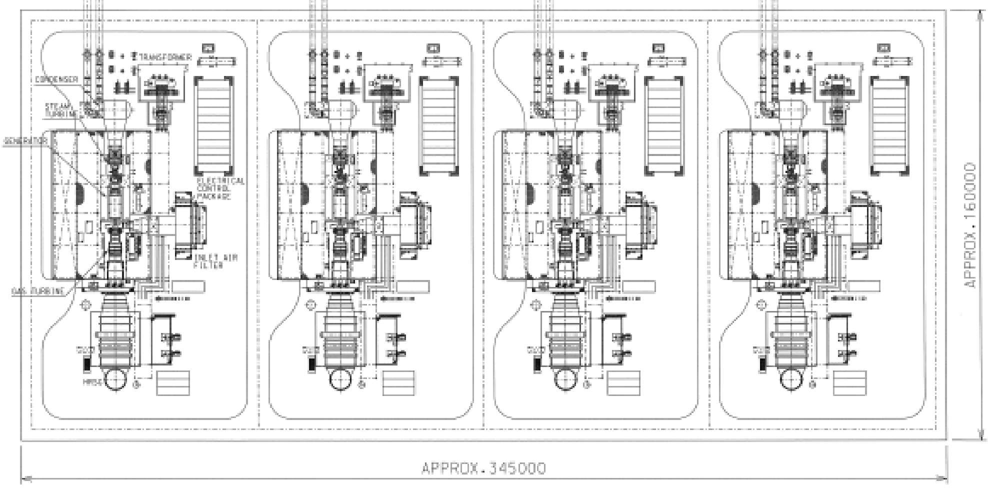
Meanwhile, in 2020, the reserve capacity could be more than 5%. Under this circumstance, such a stepwise commercial operation of CCTPP such as GT first and CCTPP second would be ineffective from the fuel cost-cutting point of view.

(d) Type layout compatibility with the site

A typical layout of main component for each CCTPP configuration is shown in Figure 4-2-4.

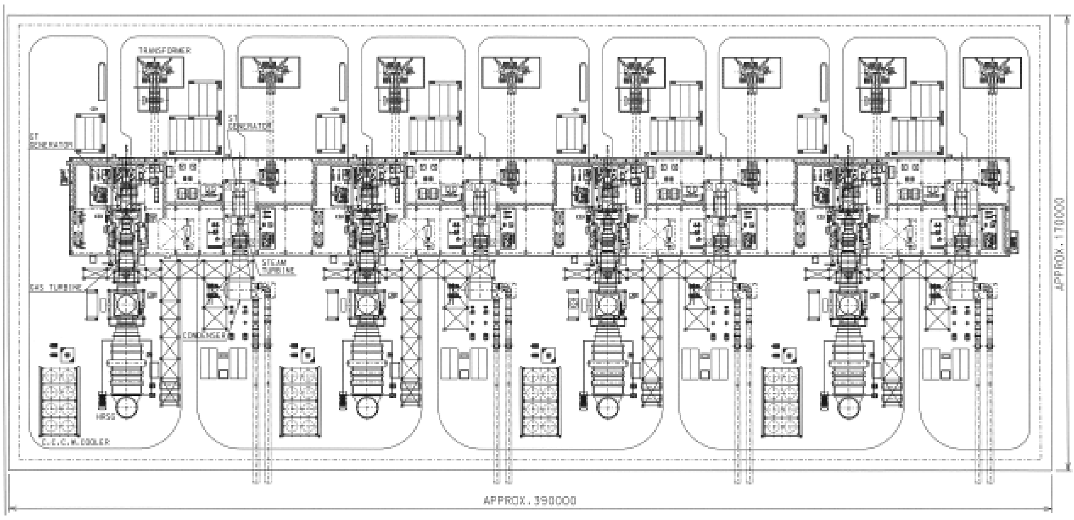
Type A

Singles haft GT 4 + ST 4



Type B

Multi shaft GT 4 + ST 4



Type C

Multi shaft GT 4 + ST 2

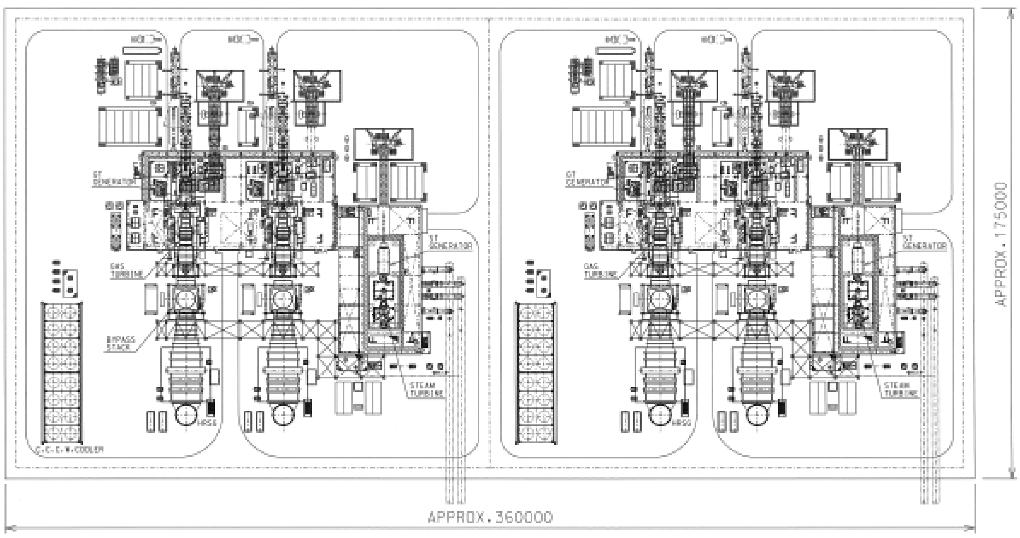


Figure 4-2-4 Typical layouts of CCTPP configurations

In any configuration, the requirement in axial length of rotating shaft is less than 175m. The candidate site is broad enough to layout the planned CCTPP plants. Meanwhile, Type C (2-on-1 multi shaft configuration) consisting of 4 GT units requires a 15m longer area in the longitudinal direction than Type A (Single shaft configuration). It is noted that an additional area for the BOP equipment is also required such as cooling plants, tanks, water treatment plants, and other utility plants.

(e) Limitation to ODC (Over Dimension Cargo) Transportation

In considering the scale of CCTPP, limitation to ODC transportation should be important. In particular, Type A (1-on-1 single shaft configuration) at 450 MW has the heaviest parts such as a stator of the generator at 300 tons that needs to consider whether it can be transported on roads and bridges along the route to the site. In case that there is weight limit along the route, the scale of CCTPP should be carefully considered. A main transformer is sometimes contrary to the weight limitation because of its weight of more than 300 tons. However, if a single phase transformer is chosen instead of a three- phase transformer, the unit weight of each transformer can be lighter so that it can be easily handled regardless of transportation limitation.

(f) Impact on the grid at forced outage

When some power plants get in trouble, demand-supply balance is lost and eventually frequency becomes lowered. Its impact is subject to the characteristics of the power system. In general, the frequency is lowered by 0.1Hz in case that 0.8 – 1.2% of the entire power supply capacity is down. Provided that the frequency is lowered by 1.5Hz, the power plants could have a problem for stable operation. Therefore, the power plant should be automatically stopped operation so as to prevent a broad area blackout.

Type C (2-on-1 multi shaft configuration) has the largest capacity (900MW) among alternatives. Assuming that its one train consisting of two GTs and one ST is stopped simultaneously, a 900MW power output becomes in short while the entire power output in Iraqi power system is expected to be 18,000MW in 2015. This might not be any severe problem for the power system operation because its shortage capacity accounts for only 5% in the entire system that might lower the frequency by only 0.5Hz.

In this regard, there would be no critical problem with any CCTPP types from the viewpoint of the power system stability.

(g) Operability

1) Starting time

Booth Type A (Single shaft CCTPP) and Type B (1-on-1 Multi shaft CCTPP) have the shorter starting time than Type C (2-on-1 Multi shaft). The scale of ST of Type C is larger than other types so that the starting time tends to get a little longer.

2) Thermal efficiency curve by output

Basically, GT is good at full capacity operation. However, it sometimes needs to operate at partial power output so as to adjust demand-supply balance although the efficiency is dramatically down during partial load operation.

Figure 4-2-5 illustrates the efficiency of each type in relation to power output. Along with Type A and Type B, it can keep the thermal efficiency high by stopping 1 out of 4 CCTPP trains when its load becomes less 75% of its full capacity. Meanwhile, Type C consists of 2 CCTPP trains so that it cannot maintain a highly efficient operation by stopping 1 CCTPP train until its load becomes less 50% of its full capacity. Therefore, Type C is disadvantageous in thermal efficiency during partial load operation.

On the other hand, Type C can furnish a larger scaled ST giving higher thermal efficiency at full load operation compared to Type A and B. Provided that the project is aiming at base power supply with the high plant factor, Type C is advantageous. In contrast, if the partial load operation occurs frequently, Type A and B are advantageous.

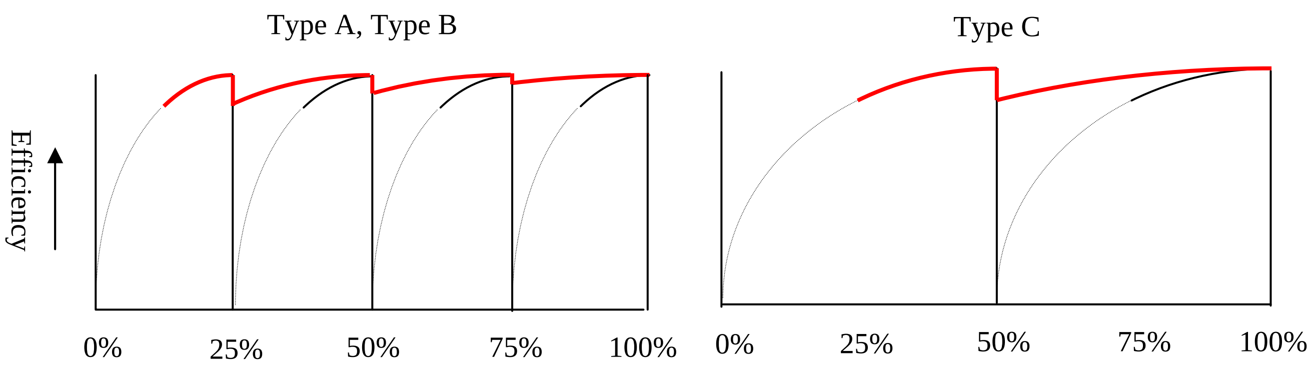


Figure 4-2-5 Effective vs. Power Output of Each Type CCTPP

3) Minimum output

As illustrated in Figure 4-2-5, the minimum output of Type A and B is thought of 12.5%. As for Type C, it is estimated to be 25%.

(h) Supply reliability

In any types, the identical assumptions are applied such as Forced Outage Rate = 6% and Scheduled Outage = 21 days / annum. Therefore, the supply reliability is identical among types provided that the installed capacity is also same.

Meanwhile, in case of 2-on-1 CCTPP (Type C), even if one GT is in trouble, it can operate at 50% rated output by using remaining one GT and one ST. This means that Type C supply reliability is comparatively a little higher. In addition, Multi shaft CCTPP system (Type B and C) is rather functional for simple cycle GT operation provided that bypass-dumper and bypass-stack are optionally equipped. This can also keep Type B and C reliable for power supply.

(i) Environmental impact (CO_2 emission)

All types can realize over 57% thermal efficiency that is more ability to control CO_2 emission. The calculated CO_2 emission is 250 million kg-CO_2/GT/annum less than that in original power M/P.

(3) Technical features of CCTPP types

Table 4-2-11 represents the technical feature of each CCTPP type.

Table 4-2-11 Technical feature of each CCTPP type

	Type A	Type B	Type C	Notes
Shaft Configuration	Single shaft 1GT＋1ST	Multi shafts 1GT＋1ST	Multi shafts 2GT＋1ST	
Construction cost	Almost same as Type C	More expensive than Type C	Base	Type B EPC cost is a bit high.
Needs and limits of power output	1 set at 1 GT		1 set at 2 GTs	Type C has less option in power output.
Simple Cycle Operation	Not applicable	Applicable with bypass dampers and stacks (Bypass damper and stacks need space and cost)		In case of power shortage, simple cycle GT commissioning prior to CCTPP is highly effective.
Construction Period	Base	Earlier commissioning if simple cycle applicable		
Foot Print	The longest shaft tends to be restrictive.	More flexible in equipment layout because of short shaft length		There's no critical issue on site area restriction regardless of CCTPP types.
Limitation to ODC transportation	Weight of Generator stator is more than 300 tons	Maximum weight is 200 tons.		The heaviest Type A needs to carefully consider ODC transportation.
Grid Compatibility	Potential impact to Grid with larger generators	Smaller generators compatible with weaker grids	Comparatively larger impact on the grid when 1 train is in forced outage.	There's no critical issue regardless of CCTPP types in terms of the scale of Iraqi power system.
Operability	A little less efficiency for smaller steam turbine A little better efficiency in partial load Shorter startup time for smaller steam turbines		A little higher efficiency for base load operation with larger steam turbine	Type C has advantage when it operates at its full capacity.
Maintenance	Free from inter-shaft interaction in maintenance		Inter-shaft interaction to be considered	There is no notable discrepancy among CCTPP types.
Reliability	Base	Available simple cycle operation with bypass dampers and stacks		There is no notable discrepancy among CCTPP types.
CO_2 emission	CO_2 emission can be largely reduced because of highly efficient CCTPP types.			There is no notable discrepancy among CCTPP types.

(4) Economic efficiency

Each CCTPP type was evaluated from the economic efficiency viewpoint. Table 4-2-12 shows general and technical specifications on each CCTPP type. For the comparison purpose, the original CCTPP feature in the PB-made power M/P is also mentioned in Table 4-2-12.

Table 4-2-12 CCTPP features for Comparison

		Plan A	Plan B	Plan C	Original (MP)
Configuration		Single shaft 1GT＋1ST	Multi shafts 1GT＋1ST	Multi shafts 2GT＋1ST	Multi shafts 2GT＋1ST
Output (Gross)		450MW S/S x 4 train Total 1,800MW	300MW GTG x 4 150MW STG x 4 Total 1,800MW	300MW GTG x 4 300MW STG x 2 Total 1,800MW	600MW x 3 1,800MW
Construction cost (USD/kW)[8]		744	799	742	1,045
Construction periods (years)		3	3	3	2.5
O&M cost	Fixed (USD/kW/year)	14.6	14.6	14.6	20.4
	Variable (USD/MWh)	3.11	3.11	3.11	2.6
Life (years)		25	25	25	25
Efficiency (%)[9]		57.3	57.1	57.3	50.1
Forced outage rate (%)		6	6	6	7
Scheduled outage (days/year)		21	21	21	25

Note: All the costs were calculated on the basis of CCTPP industrial market in USA.

Table 4-2-13 represents the present value generated thru the project period for each CCTPP type. The bottom line shows the cost difference in comparison with the original plan (600MW x 3 units). The project period is assumed as 10 years (year 2021 to year 2030). The present value is calculated by discounting cumulative costs with 10% discount rate into 2020.

Table 4-2-13 Present Value

		Plan A	Plan B	Plan C	Original (MP)
		Single shaft 1GT＋1ST	Multi shafts 1GT＋1ST	Multi shafts 2GT＋1ST	Multi shafts 2GT＋1ST
Output (Gross)		450MW x 4 1,800MW	450MW x 4 1,800MW	900MW x 2 1,800MW	600MW x 3 1,800MW
Present value at 2020 (mil. USD)	Fixed cost	34,985	35,060	34,982	35,391
	Fuel cost	45,898	45,904	45,898	46,691
	Total	80,883	80,965	80,880	82,082
	Difference	-1,198	-1,117	-1,201	Base

Plan A, B, and C can all realize a number of fuel cost reduction by more than USD100 million/year compared to the original plan. The higher thermal efficiency is contributing saving fuel consumption.

In every case, the present value of 10 year cumulative generating costs is estimated about USD 1 billion less than that of the original plan.

[8] The construction cost for Plan A, Plan B, and Plan C was estimated assuming the CCTPP plant is constructed in USA. Therefore, possible costs for Iraqi factors are not yet considered in this estimate.

[9] The figures of thermal efficiency are derived from GT-Pro estimation.

4.2.3 Recommendation of Fuel Type, Generation Type and Unit Capacity

In comparison with three alternatives in CCTPP configuration, there is no wide spread among all the plans. High thermal efficiency (57%) and moderate construction cost for all types of CCTPP could contribute choosing CCTPP fully operating in the demand-supply simulation, substituting other existing power plants which thermal efficiency and cost effectiveness are much lower than CCTPP.

In any cases, developing a 1,800MW power project does require a large amount of the investment fund. Particularly, Plan C has the larger unit capacity of 900MW and larger financial requirement compared to other plans. Therefore, the JICA study team recommends phasing the construction of two trains, so-called “Phasing Approach” in order to relieve the excessive cost burden in the short period.

Table 4-2-14 Required Capital Cost[10]

	Plan A	Plan B	Plan C
Output (Gross)	450MW x 4 sets 1,800MW	450MW x 4 sets 1,800MW	900MW x 2 sets 1,800MW
Construction cost (USD/kW)	744	799	742
Construction cost (million USD)	1,339	1,438	1,335
IDC (million USD)	182	196	182
Total (million USD)	1,521	1,634	1,517
Unit cost (million USD/set)	380	408	759

Such a larger scaled CCTPP plant (1,800MW) is expected to enhance efficient use of fuel and reduction of CO_2 emission.

In full consideration of the above-mentioned study outputs, the best available CCTPP technology is the most beneficial for Iraqi power system regardless of CCTPP configurations. Basically, there is no significant discrepancy among all CCTPP configurations.

In this regard, the study team’s recommendation is to select as large scaled CCTPP as possible within MOE’s budget. MOE also should consider transmission network capacity, fuel supply capacity, over dimensional cargo along the transportation route, and so on that sometimes sets limit to the scale of the power plants.

In addition to that, prior commissioning of simple cycle GT is quite advantageous from the viewpoint of reducing overall power generating cost in Iraqi power system in 2017. If Iraqi Government has a plan to eliminate short-term power shortage in 2016 or 2017 as a target year, selecting multi shaft CCTPP configuration and starting its operation along with simple cycle GT prior to CCTPP operation are more recommendable.

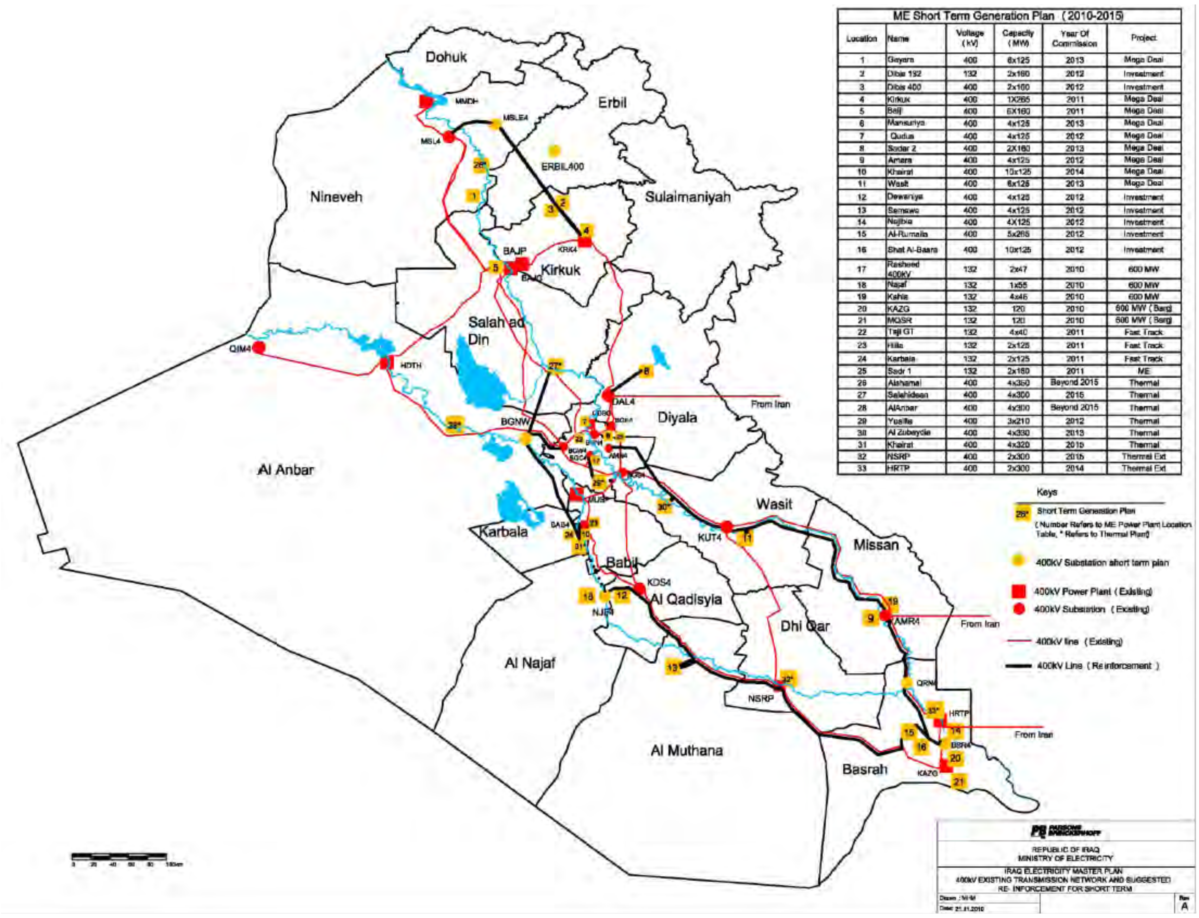
[10] Each construction cost was estimated assuming the CCTPP plant is constructed in USA. Therefore, possible costs for Iraqi factors are not yet considered in this estimate. IDC (Interest During Construction) is assumed as 13.6% of EPC net cost.

4.3 Power Network System Expansion Plan

4.3.1 Review of Power Network Expansion Plan

MOE prepared the Iraqi Power Development Master Plan (MP) in Dec. 2010. Figure 4-3-1 and Table 4-3-1 show both the power plant development plan and network expansion plan described in the MP. The total installed capacity to be developed from 2010 to 2015 is 20,293MW across the country out of which 8,324MW can affect the regional network expansion plan including Kut sub-region of Central region, Dewaniya sub-region of South-west region, and all sub-regions in Southern region. In particular, it is worth considering that Emara project (125MW x 4 units) in 2012, Nasiryah extension project (300MW x 2 units) in 2015, and Hartha extension project (300MW x 2 units) in 2014 are planned to be developed in the same period as Nasiryah II project. In the MP, 400kV transmission lines are planned to be upgraded in line with development of those power plants as shown in Table 4-3-1. Those upgrading projects will add 1,159km in length of the transmission line and 2,000MVA in transmitting capacity increasing the number of conductors from two to four as well as the number of circuits from one to two.

MOE itself has modified its MP in 2010 reflecting changes of the circumstances surrounding Iraqi power sector. Based upon modification, Table 4-3-2 shows the modified plan for the upgrading of 400kV transmission lines. The total expansion length is 4,889km out of which 3,691km will be installed by 2015. The total length of transmission lines would nearly triple compared to the existing 1,159km lines. As for construction process, two- or three-circuit transmission lines will add to the both existing eastern route and western route. JICA Study Team believes that implementing the expansion plan of transmission network as planned is a key for successful power sector development.



ME Short Term Generation Plan (2010-2015)					
Location	Name	Voltage (kV)	Capacity (MW)	Year Of Commission	Project
1	Geyara	400	6x125	2013	Mega Deal
2	Dibis 132	132	2x160	2012	Investment
3	Dibis 400	400	2x160	2012	Investment
4	Kirkuk	400	1X265	2011	Mega Deal
5	Baiji	400	6X160	2011	Mega Deal
6	Mansuriya	400	4x125	2013	Mega Deal
7	Qudus	400	4x125	2012	Mega Deal
8	Sadar 2	400	2X160	2013	Mega Deal
9	Amara	400	4x125	2012	Mega Deal
10	Khairat	400	10x125	2014	Mega Deal
11	Wasit	400	6x125	2013	Mega Deal
12	Dewaniya	400	4x125	2012	Investment
13	Semawa	400	4x125	2012	Investment
14	Najibia	400	4X125	2012	Investment
15	Al-Rumaila	400	5x265	2012	Investment
16	Shat Al-Basra	400	10x125	2012	Investment
17	Rasheed 400KV	132	2x47	2010	600 MW
18	Najaf	132	1x55	2010	600 MW
19	Kahla	132	4x46	2010	600 MW
20	KAZG	132	120	2010	600 MW (Barg)
21	MQSR	132	120	2010	600 MW (Barg)
22	Taji GT	132	4x40	2011	Fast Track
23	Hilla	132	2x125	2011	Fast Track
24	Karbala	132	2x125	2011	Fast Track
25	Sadr 1	132	2x160	2011	ME
26	Alshamal	400	4x350	Beyond 2015	Thermal
27	Salahideen	400	4x300	2015	Thermal
28	AlAnbar	400	4x300	Beyond 2015	Thermal
29	Yusifia	400	3x210	2012	Thermal
30	Al Zubaydia	400	4x330	2013	Thermal
31	Khairat	400	4x320	2015	Thermal
32	NSRP	400	2x300	2015	Thermal Ext
33	HRTP	400	2x300	2014	Thermal Ext

Source：Iraq Electricity Master Plan Dec. 2010 by Parsons Brinckerhoff

Figure 4-3-1 Power Network Expansion Plan

Table 4-3-1 400kV Reinforcement Requirement

(km)

Line specification	Capacity per circuit (MVA)	2010	2011	2012	2013	2014	2015	Total
1 circuit, 4 conductors	>2000	0	0	220	0	0	0	220
2 circuits, 4 conductors	>2000	0	0	0	0	0	230	230
1 circuit, 2 conductors	1000	0	0	663	0	0	0	663
2 circuits, 2 conductors	1000	0	0	46	0	0	0	46
Total								1,159

Source：Iraq Electricity Master Plan Dec. 2010 by Parsons Brinckerhoff

Table 4-3-2 400kV Line Development Plan Modified in 2010 by MOE

From	To	Length (km)	No. of conductors	No. of circuits	Capacity (MVA)	Completion year
Gayarra	Mosul4	104	2	2	1,000	2012
Gayarra	Baiji thermal	79	2	1	1,000	2012
Gayarra	Shamal	40	2	1	1,000	2014
Khairat	Babil4	50	2	1	1,000	2012
Khairat	Kadissiya4	50	2	1	1,000	2012
Khairat	BGC4	80	2	1	1,000	2013
Najibiya	Hartha	15	2	1	1,000	2013
Najibiya	Khor Al-zubair	40	2	1	1,000	2013
Najibiya	Shat al-basra	25	2	1	1,000	2013
Najaf	Babil4	100	2	1	1,000	2013
Najaf	Kadissiya4	104	4	1	2,774	2014
Najaf	Samawa	140	4	1	2,774	2013
Najaf	BGC4	140	2	1	1,000	2014
Shat al-basra	Basra4	54	2	2	1,000	2013
Shat al-basra	Rumaila	50	2	1	1,000	2013
Shat al-basra	Emara4	150	2	1	1,000	2014
Samawa	Kadissiya4	104	4	1	2,774	2013
Samawa	Nasiryah thermal	100	2	1	1,000	2013
Samawa	Nasiryah g.p.s	100	2	2	1,000	2014
Dewaniya	Kadissiya4	12	2	2	1,000	2013
Emara	Qurna	80	2	1	1,000	
Nasiryah g.p.s	Rumaila	145	2	1	1,000	2015
Nasiryah g.p.s	Kadissiya4	176	2	1	1,000	2015
Saddir	Baghdad east	15	2	1	1,000	2013
Saddir	Quds g.p.s	15	2	1	1,000	2013
Baiji g.p.s2	Baiji thermal	15	2	1	1,000	2013
Baiji g.p.s2	Baghdad west	242	2	1	1,000	2013
Dibis	Kirkuk	55	2	1	1,000	2013
Dibis	Mosul east	120	2	1	1,000	2013
Rumaila	Nasiryah thermal	145	2	1	1,000	2013
Rumaila	Khor Al-zubair	80	2	1	1,000	2013
Mansuriya	diyala4	60	2	1	1,000	2013
Mansuriya	Rusafa	120	2	1	1,000	
Mansuriya	Kirkuk	196	2	1	1,000	2013
wassit-1	Kut4	20	2	2	1,000	
wassit-1	Baghdad south	140	2	1	1,000	
wassit-2	Rusafa	120	4	2	2,774	2014
wassit-2	Baghdad south	140	2	1	1,000	2014
wassit-2	Ameen4	140	2	1	1,000	2014
Shamal	Baiji thermal	100	2	1	1,000	2014
Shamal	Mosul 4	70	2	1	1,000	2015
Shamal	Mosul east	70	2	1	1,000	
Anbar	Qa'im	128	2	1	1,000	
Anbar	Haditha	100	2	1	1,000	
Anbar	Baghdad west4	100	4	1	2,774	
Anbar	Baghdad north west	120	2	1	1,000	
Salah Al-deen	Baghdad north west	80	2	1	1,000	
Salah Al-deen	diyala4	90	2	1	1,000	2014
Salah Al-deen	Kirkuk	230	2	1	1,000	2014
Salah Al-deen	Rusafa	120	2	1	1,000	
Rusafa	Ameen4	20	2	1	1,000	
Baghdad east	Rusafa	20	4	1	2,774	
Baghdad north	Baghdad north west	30	2	1	1,000	
Baghdad west	Baghdad north west	10	2	1	1,000	
Bgc4	Baghdad north west	40	2	1	1,000	
Total Length (km)	4,889km (3,691km: completion year indicated, 1,198km: not indicated) (588km: Cap. 2,774MVA, 4,301km: 1,000MVA) (306km: 2 circuits, 4,583km: 1 circuit)					

Source：MOE

4.3.2 Revised Network System Expansion Plan

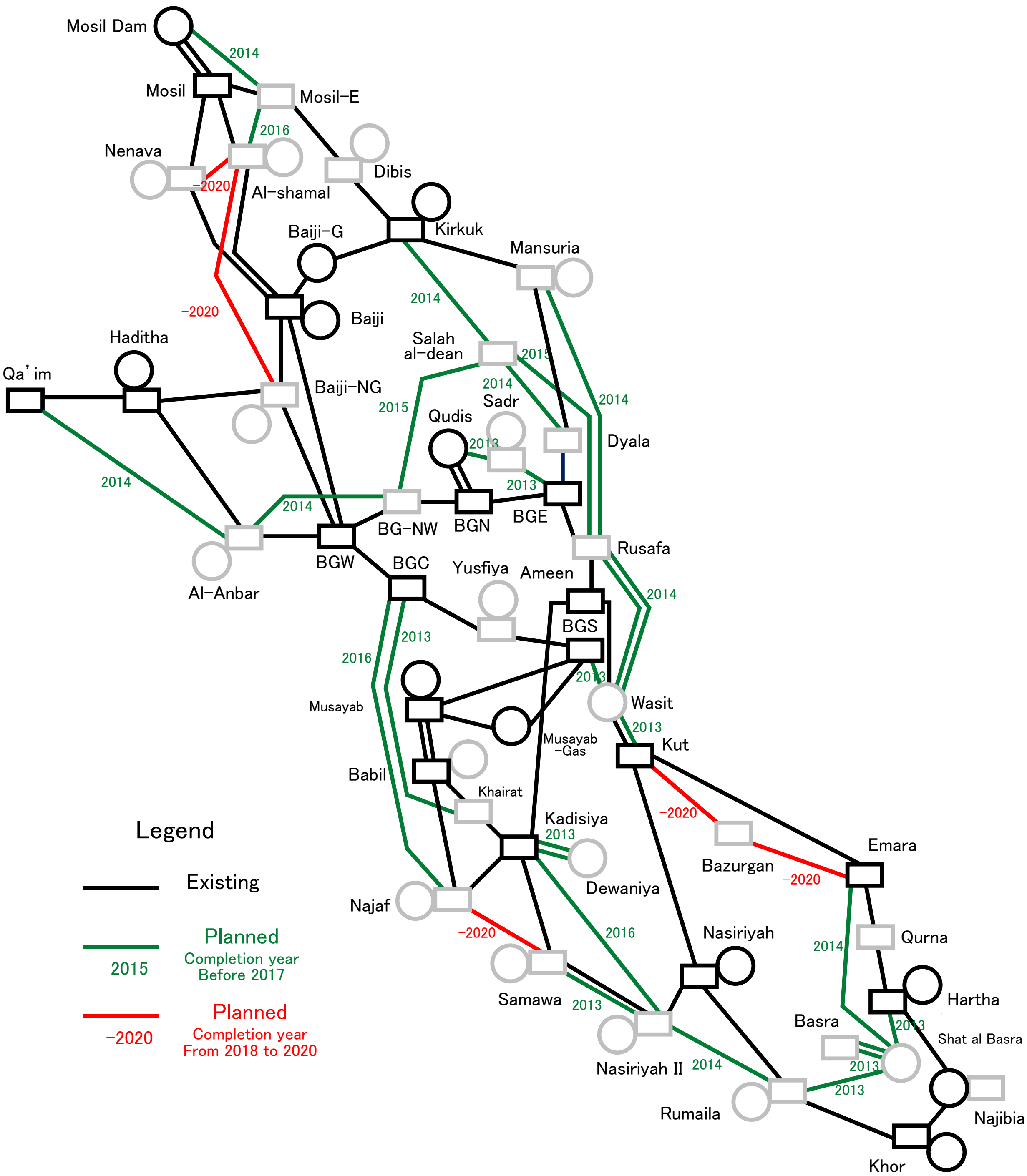
Based upon power generation profiles of Nasiryah I and Nasiryah II projects, MOE once again revised its network expansion plan as shown in Table 4-3-2 “400kV Line Development Plan Modified in 2010 by MOE”.

Figure 4-3-2 shows the latest network expansion plan illustrating the existing transmission lines in black, the planned lines to be installed by 2017 in green, and the other planned lines to be installed in 2018 thru 2020 in red, respectively. In consideration of development of large amount of active power, transmission lines between Southern area and Baghdad need to be reinforced.

As the power generated by Nasiryah II project is to be transmitted through the west transmission route, the following profile of the western transmission lines is considerable;

Exiting : 1 circuit (Nasiryah II－Kasisiya－Baghdad South(BGS)
In 2016 : 3 circuits (Partially 2 circuit, because of late completion of Samawa－Najaf line)
In 2018 : 3 circuits

In the latest network expansion plan, Samawa－Najaf line is planned to put into operation in somewhere between 2018 and 2020. Assuming it puts into operation in 2019 or 2020, Kadisiya substation could be a bottleneck in the power system because only two circuits are available in 2018 when Nasiryah II and other southern power projects are into operation.



Source：Created by JICA Study Team with reference to network expansion data provided from MOE

Figure 4-3-2 Revised power network expansion plan

4.3.3 Forecasted power flow after completion of Nasiryah II

(1) Target year for power flow analysis

In order to assess stability of power transmitting, power flows were analyzed to check whether there have any issues such as overload. Assumptions for the analysis are as follows;

- Nasiryah II 1 unit into operation: 2017
- Nasiryah II 2 units into operation: 2018

(2) Network system to be analyzed

Based upon the network data for PSSE in 2015 and 2020 provided by MOE, JICA Study Team itself created data for the calculation target years such as 2017 and 2018. Assumptions are made as follows;

- Power demands both in 2017 and 2018 are proportionately calculated based upon the demands in 2015 and 2020.
- Power outputs of the existing Nasiryah power plant and the Nasiryah I project are set out constantly at 568MW and 500MW respectively. (where the existing Nasiryah plant is assumed to achieve 90% of the rated output due to deterioration.)
- Nasiryah II project 900MW (1 unit) puts into operation in 2017 and then 1,800MW (2 units) in 2018.
- Network configuration is assumed to be as shown in Figure 4-3-2

(3) Power flow analysis results

Power flows in 2017 (Nasiryah II 1 unit in operation) and in 2018 (Nasiryah II 2 units in operation) are estimated as shown in Figure 4-3-3, Figure 4-3-4 respectively. Table 4-3-3 summarizes noticeable power flows in the southern region to be affected by Nasiryah II project. The outlines of analysis results are as follows;

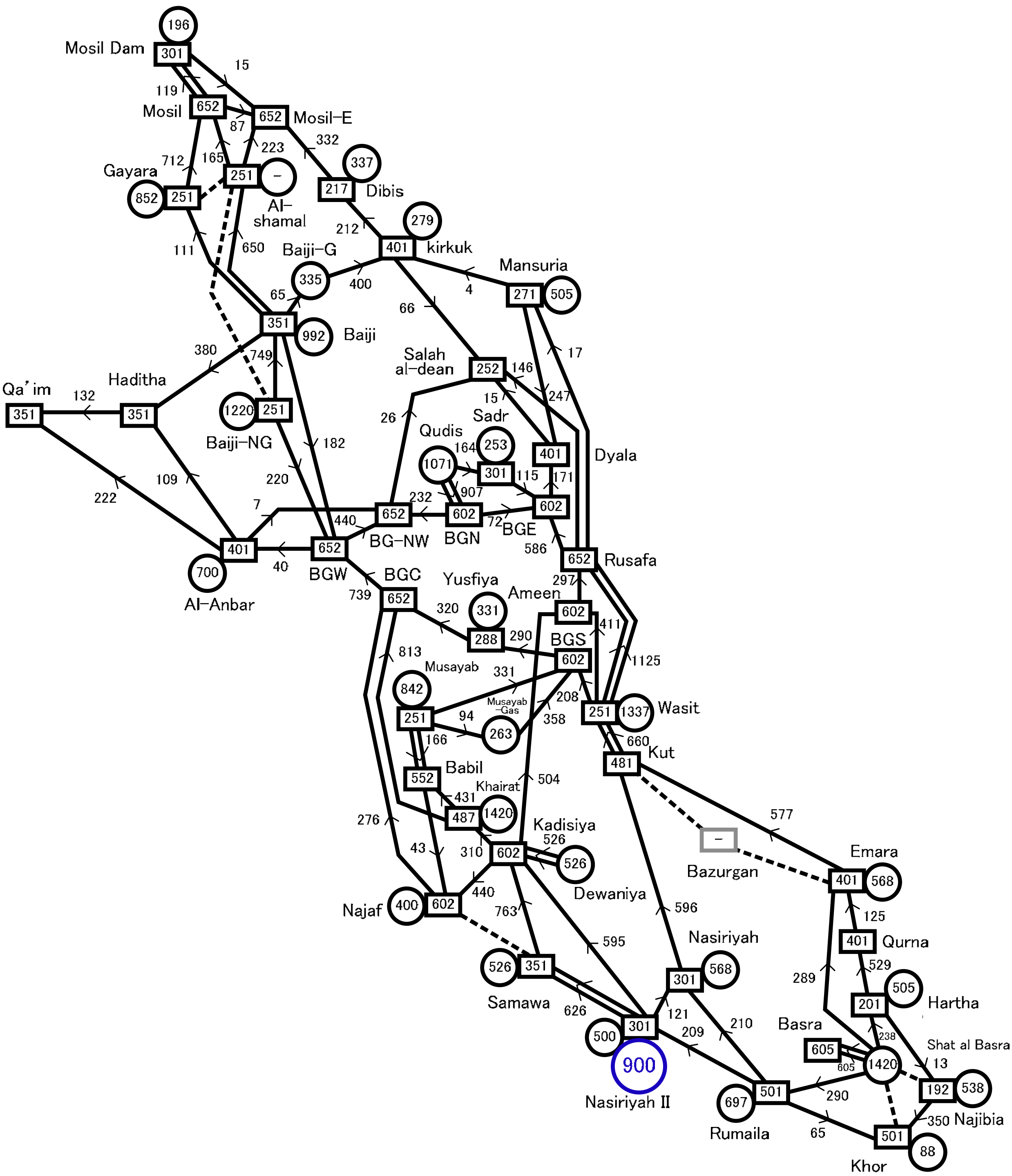
- The number of circuits became two or three in west transmission line route from Nasiryah II to Central region.
- In 2017 (Nasiryah II 1 unit in operation), the maximum power flow in a circuit is estimated to be 813MW in the planned Khairat－Baghdad Central line. It is within the transmitting capacity of 950MW.
- In 2018 (Nasiryah II 2 units in operation), the maximum power flow appears at 1,014MW exceeding the transmitting capacity 950MW in Samawa－Kadisiya line. The reason of the overloading is insufficient power transmitting capacity between Samawa and Kadisiya before a new bypass line between Samawa and Najaf starts operation in 2020. Provided that the bypass line put into operation in 2018, the overloading could not occur.

In conclusion, MOE needs to modify its power system development plan in consideration of concrete commercial operation dates of the planned power projects including Nasiryah II project. MOE, thereby, can well harmonize the schedule of the power projects with the power network projects. In particular, the planned transmission line between Samawa and Najaf should be completed construction even before Nasiryah II starts full operation at 1,800MW in 2018.

Table 4-3-3 Power flow in major 400kV transmission lines (MW/circuit)

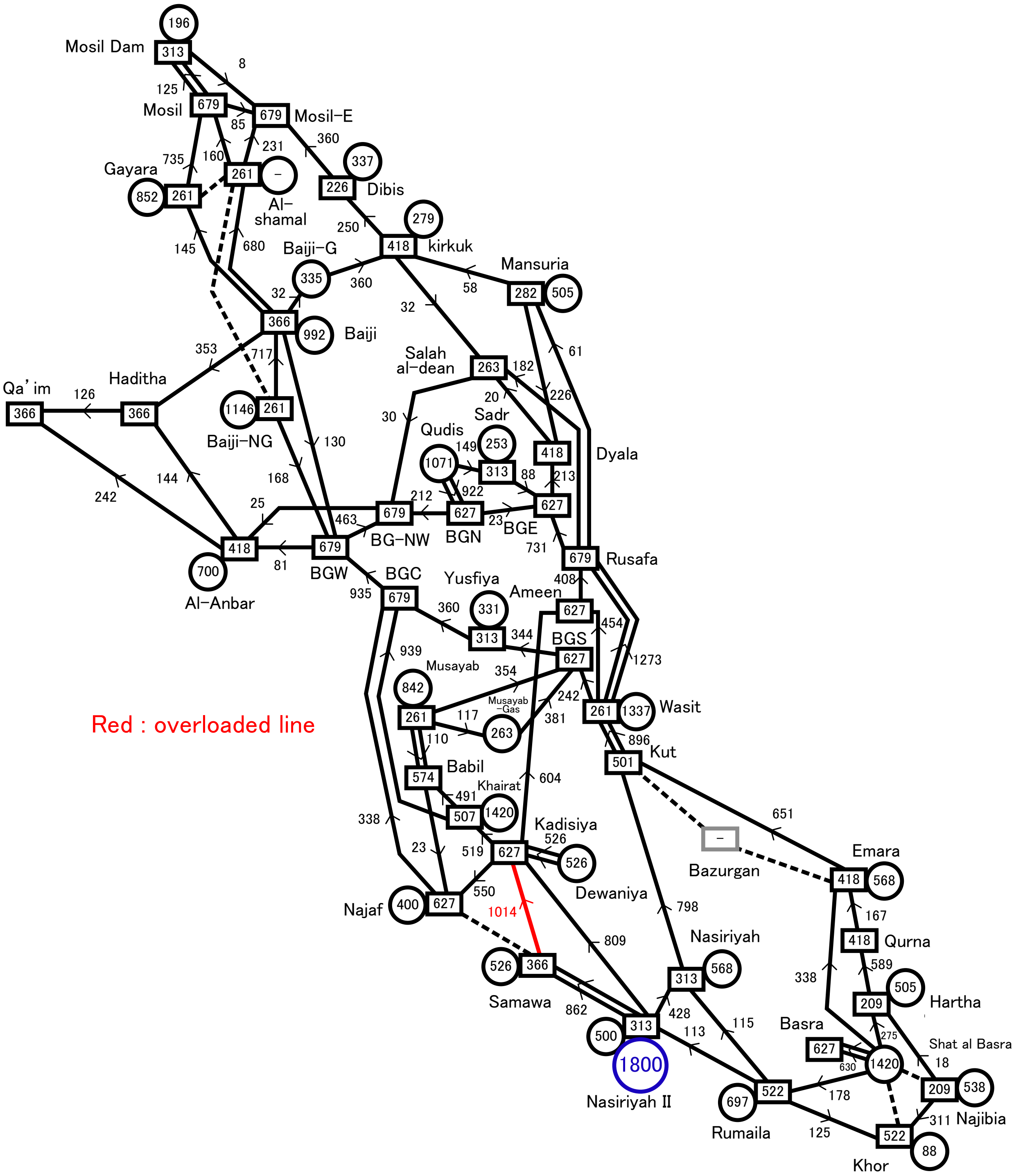
Line	Transmitting capacity (MW)	Year 2017	Year 2018
		Nasiryah II 900MW	Nasiryah II 1800MW
Nasiryah II－Nasiryah	950	121	428
Nasiryah－Kut	950	596	798
Nasiryah II－Kadisiya	>950	595	809
Nasiryah II－Samawa	950	313	431
Samawa－Kadisiya	950	763	1014
Najaf－Baghdad Central	>950	276	338
Khairat－Baghdad Central	>950	813	939
Baghdad Central－Baghdad West	950	739	935

Source：JICA Study Team



Source : The Study Team

Figure 4-3-3 Power flow after 900MW development at Nasiriyah II in 2017



Source : The Study Team

Figure 4-3-4 Power flow after 1800MW development at Nasiryah II in 2018

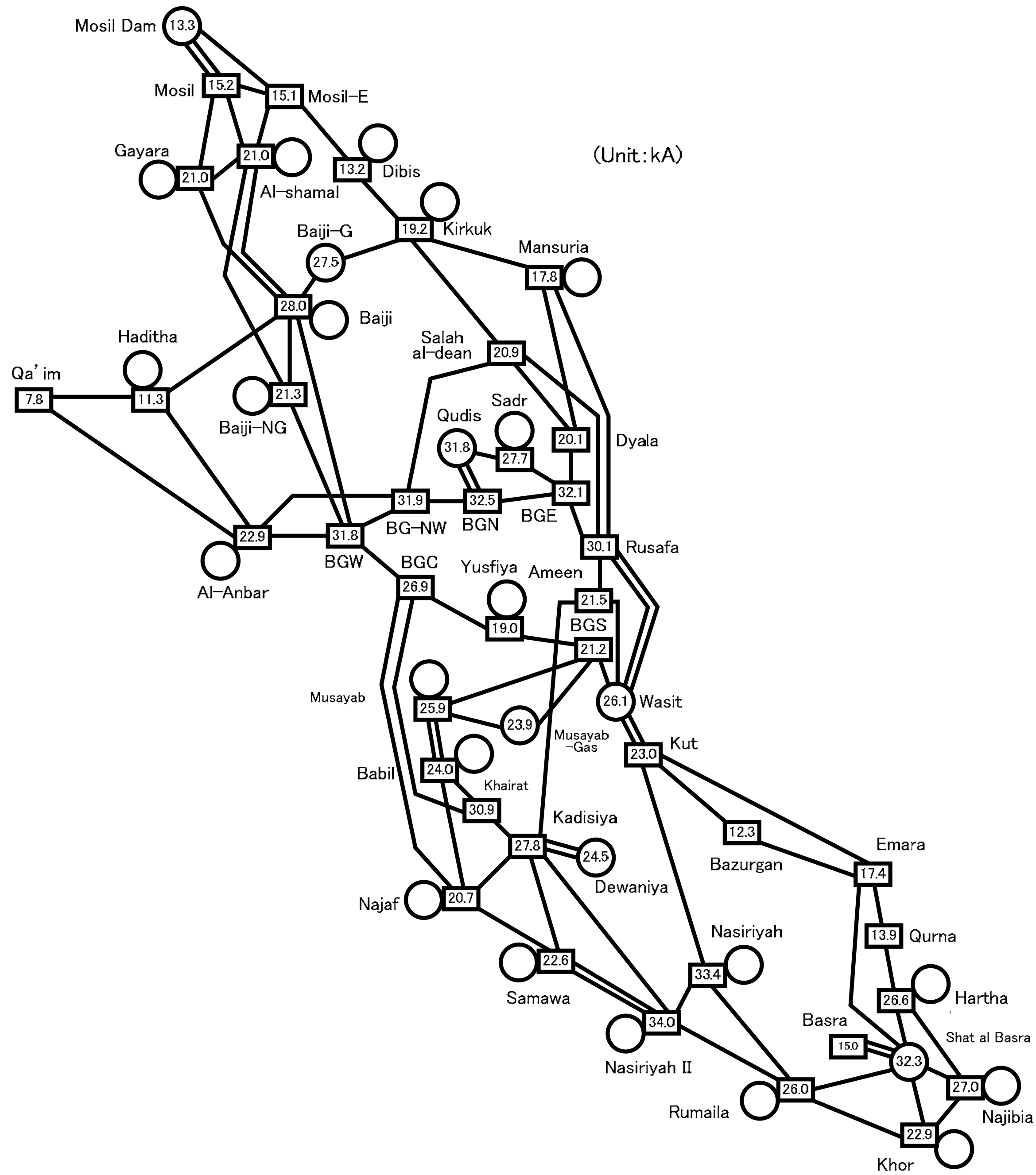
(4) Fault current analysis results

Although the calculation target years are 2017 and 2018, the fault current analysis was executed by using the PSSE data in 2020. But this is a common practice for the planning of appropriate power system configuration aiming at the network stability for as long periods as possible.

Figure 4-3-5 shows the result from the fault current analysis in 2020. The maximum fault current in each region is as follows;

- Baji in Northern region: 28.0kA
- Kirkuk in Eastern region: 19.2kA
- Baghdad North in Central region: 32.5kA
- Al Anbar in Western region: 22.9kA
- Khairat in South-west region: 30.9kA
- Nasiryah in Southern region: 34.0kA.

Since a lot of power plants are developed in South region, relatively large increases of the fault current are observed around South regional system. However, those are still less than the rated breaking current of the 40kA circuit breakers. Therefore, it is judged that there would be no problem.



Source : Network analysis result using PSSE data of MOE

Figure 4-3-5 Fault Current in 400kV Network in 2020

4.3.4 Conclusion

In conclusion, noticeable implications for the power system development are as follows;

- For full harmonization of the schedule of the power projects with the power network projects, MOE needs to modify its power system development plan in consideration of concrete commercial operation dates of the planned power projects including Nasiryah II project.
- In 2017 (Nasiryah II 1 unit in operation), the maximum power flow in a circuit is estimated to be 813MW in the planned Khairat－Baghdad Central line.　It is within the transmitting capacity of 950MW.
- In 2018 (Nasiryah II 2 units in operation), the maximum power flow appears at 1,014MW exceeding the transmitting capacity 950MW in Samawa－Kadisiya line.　The reason of the overloading is insufficient power transmitting capacity between Samawa and Kadisiya before a new bypass line between Samawa and Najaf starts operation in 2020.　Provided that the bypass line put into operation in 2018, the overloading could not occur.

Chapter 5

Implementation of Feasibility Study

Chapter 5 Implementation of Feasibility Study

5.1 General information around Construction Site

5.1.1 Meteorological Condition

(1) Air Temperature

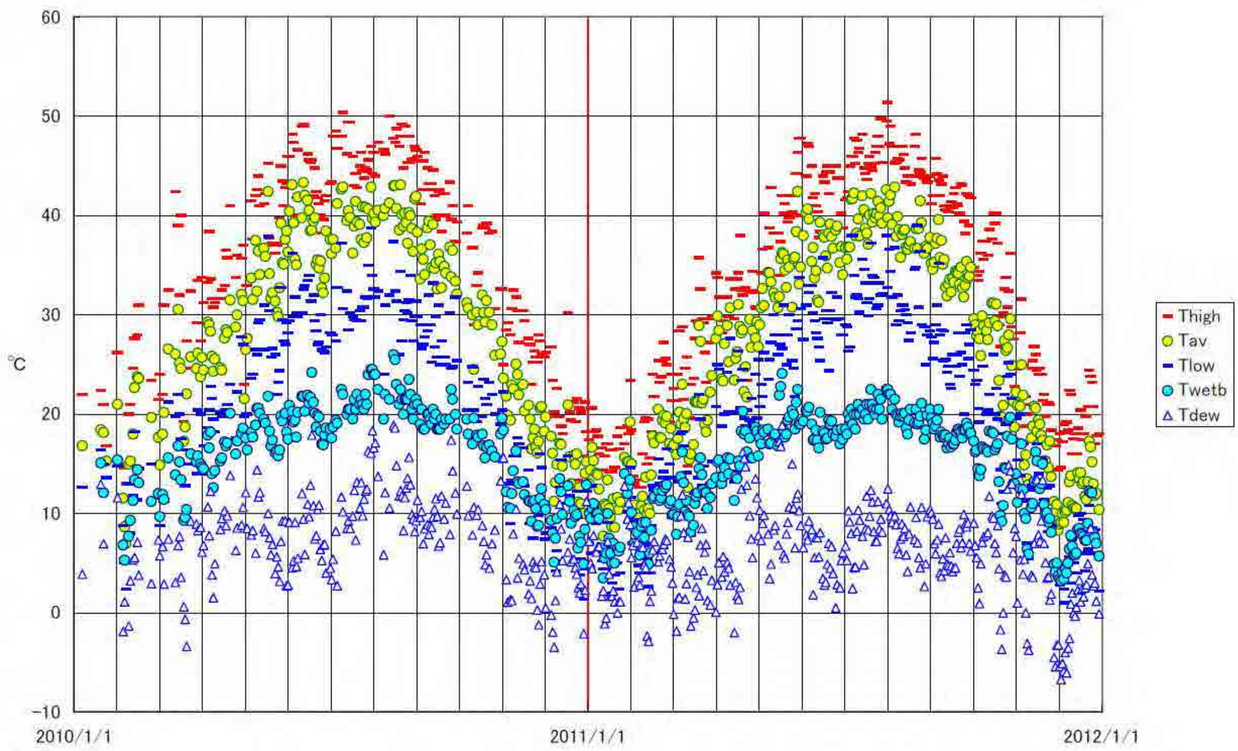
Maximum monthly mean air temperature of 40.2°C (observed in July 2000) and minimum monthly mean air temperature of 9.0°C (observed in Jan. 1992) were observed in the Al Nasiryah meteorological station close to the project site.

Table 5-1-1 Monthly Mean Air Temperature (ºC) [at Al Nasiryah meteorological station]

YEAR	JAN	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
1992	9.0	11.9	15.2	24.0	29.7	34.9	35.7	36.2	33.1	26.1	18.4	12.4
1993	10.7	13.3	19.0	24.3	30.1	35.3	37.4	37.1	33.4	28.1	18.0	15.4
1994	14.9	15.4	20.3	27.2	32.3	35.4	36.4	35.8	34.0	28.2	20.2	11.1
1995	13.4	15.4	19.7	24.9	32.5	35.9	36.4	36.7	32.5	26.5	18.7	13.0
1996	13.4	15.9	19.1	24.7	33.8	36.0	39.2	38.2	33.4	26.7	19.7	16.6
1997	12.9	12.1	16.6	24.4	32.7	36.7	36.7	34.9	33.4	27.8	19.4	13.6
1998	11.3	14.3	18.1	25.9	31.7	37.4	38.3	39.4	34.7	27.2	21.8	16.4
1999	14.0	15.8	19.6	26.9	33.5	37.0	37.9	39.1	34.4	29.2	19.1	13.5
2000	12.0	14.1	19.2	28.9	33.2	36.1	40.2	39.5	33.5	26.2	18.4	13.6
2001	12.3	15.4	21.4	26.9	32.0	35.0	37.2	39.3	34.7	28.8	19.0	15.9
2002	11.6	15.5	21.2	24.7	32.4	36.3	38.9	37.1	34.4	29.4	18.8	13.4
2003	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	15.2	21.6	24.4	31.7	36.2	38.4	37.0	33.8	29.7	20.2	10.9
2005	-	13.9	19.7	26.7	32.8	36.1	38.9	37.8	32.8	26.9	17.5	15.6
2006	12.8	15.4	20.9	26.2	33.3	37.8	38.2	39.0	33.6	29.6	17.6	10.2
2007	10.2	15.8	19.5	25.2	34.0	36.9	38.1	38.4	34.6	29.1	20.1	13.2
2008	9.1	14.4	23.0	28.1	32.9	36.8	38.4	38.9	35.2	27.6	19.4	13.0

At the basic design stage, it was newly developed that the maximum temperature exceeded 50°C in the daytime from every May to September in Nasiryah city. Figure 5-1-1 shows the daily temperature record observed at the meteorological station about 5km far from the planned Nasiryah II site.

Over 40°C must make trouble to condenser vacuum, provided that an air cooled condenser (ACC) is applied as an alternative for steam turbine condenser cooling. This needed to be carefully considered in the designing of plants.



(source: US National Climatic Data Center)

Figure 5-1-1 Daily temperature record in Nasiryah City

(2) Relative Humidity

Maximum monthly mean relative humidity of 81% (observed in Dec. 1997) and minimum monthly mean relative humidity of 19.0% (observed in Jun. 2006, Jul. 2005, 2006 and 2008) were observed in the Al Nasiryah meteorological station close to the project site.

Table 5-1-2 Monthly Mean Relative Humidity (%) [at Al Nasiryah meteorological station]

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
1992	64	61	60	43	38	27	23	26	30	36	63	75
1993	74	66	50	60	38	25	21	25	28	38	58	65
1994	71	53	45	39	27	22	22	23	29	46	63	70
1995	76	66	50	44	28	23	23	25	32	34	43	65
1996	76	71	64	46	35	21	20	22	27	35	53	62
1997	67	48	56	47	31	25	22	26	29	46	71	81
1998	77	67	63	47	34	26	26	25	32	38	50	55
1999	73	69	58	44	27	21	21	21	29	37	55	72
2000	68	56	42	38	30	23	23	25	27	40	58	80
2001	-	-	-	-	-	-	-	-	-	-	-	-
2002	68	57	45	49	31	24	22	24	27	36	52	-
2003	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	61	42	39	32	26	21	23	25	37	59	68
2005	67	61	52	43	30	23	19	23	28	37	52	62
2006	67	67	45	44	29	19	19	22	27	39	57	73
2007	69	58	46	45	28	20	20	22	24	36	43	60
2008	65	49	35	28	25	20	19	22	30	45	56	56

(3) Rainfall

Maximum monthly rainfall of 105.7mm (observed in Pr. 2002) and minimum monthly rainfall of 0mm (observed from Jun. to Oct.) were observed in the Al Nasiryah meteorological station close to the project site.

Table 5-1-3 Monthly Rainfall (mm) [At Al Nasiryah meteorological station]

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2000	21.5	4.1	1.5	1.0	1.3	0.0	0.0	0.0	0.0	4.0	7.6	67.0	108.
2001	5.0	3.1	9.1	0.001	0.2	0.0	0.0	0.0	0.0	0.1	3.0	42.0	62.9
2002	10.4	7.4	11.4	105.7	1.0	0.0	0.0	0.0	0.0	1.0	8.7	5.4	151.0
2003	-	-	-	-	-	-	-	-	-	-	-	-	-
3004	28.5	0.3	0.8	25.9	0.0	0.0	0.0	0.0	0.0	0.0	26.5	16.6	98.6
2005	45.2	0.9	33.7	3.9	0.001	0.0	0.0	0.0	0.0	0.0	0.2	21.8	105.7
2006	27.5	59.5	6.1	25.2	1.9	0.0	0.0	0.0	0.0	26.9	17.7	81.0	245.8
2007	9.2	0.1	75.8	5.5	0.001	0.0	0.0	0.0	0.0	0.0	0.001	21.9	112.5
2008	19.4	10.8	0.4	1.4	0.2	0.2	0.001	0.0	0.2	32.2	0.7	0.0	65.5
2009	0.3	7.1	18.6	4.8	1.5	0.0	0.0	0.0	0.0	0.2	1.7	22.3	56.9
2010	2.6	2.7	0.5	29.2	14.8	0.0	0.0	0.0	0.0	0.1	0.4	7.3	57.6

(4) Wind

Maximum monthly mean wind velocity of 9.3m/s. (observed in Jul. 1992) and minimum monthly mean wind velocity of 1.3m/s. (observed in Nov. 2000) were observed in the Al Nasiryah meteorological station close to the project site. The wind bellows mainly from the north, northwest and west.

Table 5-1-4 Monthly Wind Velocity and Direction

[Upper: Wind Velocity (m/s) Lower: Wind direction]

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
1992	3.9	5.2	4.6	5.5	5.5	6.5	9.3	5.6	4.0	3.7	4.0	4.5
	NW	NW	NW	NW	NW	N/NW	N/NW	NW	N	N/NW	NW	NW
1993	2.9	4.7	4.7	4.4	5.4	6.6	7.6	4.6	5.0	2.6	4.3	2.9
	NW	NW	N	SE	N	N	N/NW	N	N	N	N	N
1994	3.7	4.2	5.1	4.9	5.7	6.4	4.7	4.3	1.9	2.8	3.9	2.6
	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
1995	2.5	3.3	3.9	5.1	4.3	5.5	8.2	6.4	3.5	2.7	3.7	1.8
	NW	NW	NW	E	W	NW	NW	NW	NW	NW	NW	NW
1996	3.4	3.8	4.3	5.1	3.7	5.7	5.1	4.9	5.9	3.7	2.5	3.7
	SE/NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	W/NW	E
1997	3.2	3.0	3.7	3.5	3.3	3.7	6.9	6.3	2.5	2.6	2.4	2.6
	NW	NW	NW	NW	NW	NW	NW	N/NW	N/NW	W/NW	W/NW	W/NW
1998	3.0	2.9	4.4	3.9	3.7	4.8	4.5	4.0	4.9	2.6	2.0	2.8
	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW/W	NW
1999	3.2	2.4	3.3	3.9	4.4	5.2	6.2	5.4	4.5	2.5	2.4	1.4
	W	W	W	NW	NW	NW	NW	NW	NW	NW	W	W
2000	2.7	3.5	4.7	3.7	4.6	6.2	4.3	3.6	3.6	3.0	1.3	2.6
	N/NW	NW	NW/W	NW	NW	W/NW	W/NW	NW	NW/W	NW	NW/W	NW
2001	-	-	-	-	-	-	-	-	-	-	-	-
	W	W	W	NW	NW	W/NW	W	NW	NW	NW	W	NW
2002	3.1	3.7	3.8	3.9	3.3	4.2	3.8	5.2	4.2	2.5	3.1	-
	W	W	W	NW	NW	NW	NW	NW	NW	NW	W/NW	-
2003	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	2.4	2.6	4.8	2.9	4.1	3.3	3.7	2.1	1.6	3.2	2.1
	-	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
2005	2.7	2.5	3.2	3.6	2.6	6.2	4.0	3.4	3.6	2.1	1.9	1.9
	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
2006	2.2	2.8	3.6	3.3	3.3	4.5	5.2	3.8	3.3	3.0	2.5	2.2
	NW	NW	NW	NW	NW	NW	NW	NW	NW/W	NW/W	NW/W	W
2007	2.4	2.8	3.1	3.4	2.9	4.3	3.4	3.6	4.0	2.4	2.4	2.8
	W	W/NW	W	E	NW	NW/W	W	W	NW/W	NW	NW/W	W
2008	1.9	3.9	2.2	3.2	3.2	5.1	3.6	3.3	3.0	3.1	2.3	2.7
	NW/W	NW	NW	NW	NW	NW	NW	NW	NW/W	NW	W	W

5.1.2 General Description of the Geomorphology and Geology[11]

The followings are extracted from the explanation paper of Al-Nasiriya quadrangle (scale; 1/250,000) issued by Consultant Bureau of Iraq - Applied geology Department, and are arranged based on the local condition surrounding the survey area.

(1) General feature

The project area is mostly covered by Mesopotamian plain. Geomorphology surrounding the project area is categorized into three zones, such as desert plateau, agricultural area and abandoned area, and the site is in the agricultural area along the Euphrates River (see Figure 5-1-2).

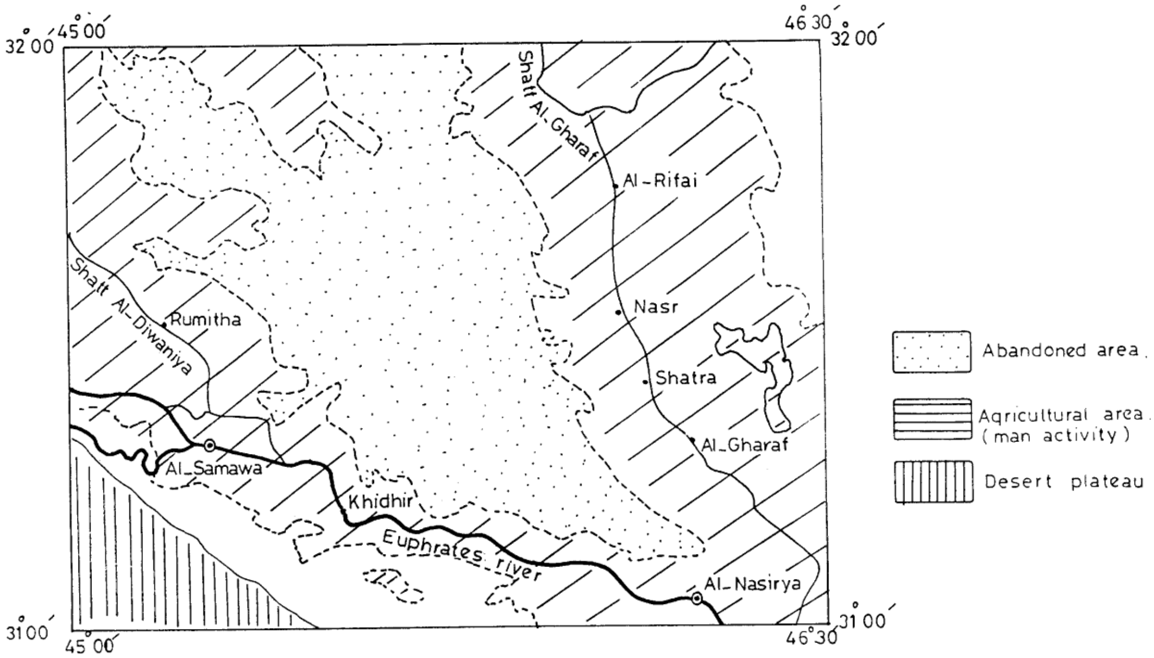


Figure 5-1-2 General sketch shows the agricultural and abandoned areas of the project area

The project area lies in the unstable shelf (Mesopotamian zone). The Mesopotamian zone was subdivided into Euphrates and Tigris subzones. Their boundary according to Buday and Jassim (1984) is defined as non tectonic or non characterized, and also the boundary between the Euphrates subzone and Samawa subzone, which is in the south to the Euphrates subzone, is marked as normal fault.

The exposed geological formations surrounding the project area is the quaternary deposits, which is mainly covers the Mesopotamian plain. They are summarized in the Table-5-1-5.

On such environmental conditions, the sediments have been formed due to the sea level rise during the post-glacial episode shown in Figure 5-1-3[12].

[11] Explanation paper of Al-Nasiriya quadrangle (scale; 1/250,000), issued by Consultant Bureau- Applied geology Depart. -Science College –Babylon University 2009 (referred from the Report of soil Investigation for Electrical Gas Turbine Power Plant project in Nasiryah city, Thi Qar Governorate.)

[12] Fleming et al. 1998, Fleming 2000, Milne et al. 2005

Table 5-1-5 Revised FS Site Investigation Plan

Geological age	Name of the Formation	Environment and Facies	
Holocene	Hammar Formation	Clay deposits / in brackish and saline water Swampy area in the river mouth of the Euphrates and Tigris	
Pleistocene	Bakhtiari Formation	Sand hills, sandbars / in the river mouth	Depression of Mesopotamian geoanticline and rise up of anticline River terrace occurred
		Alternation of clay and sand /river deposits	
	Dibdibba Formation	Fan deposits, flood plain deposits / in the hillside area	

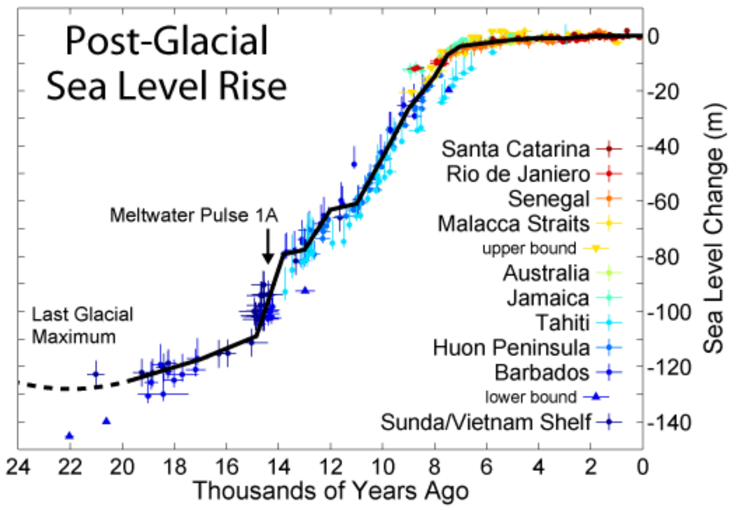


Figure 5-1-3 Sea Level Rise since the end of the last glacial episode

(2) Stratigraphy

Upon these geological histories, the site is on the Holocene deposits and their bearing layer for the structures will be placed on the deposits of Pleistocene of Neogene. They include different types of deposits and are classified due to their genesis as fluvial, lacustrine, aeolian, polygenetic, anthropogenic deposits, and gypcrete.

According to the existing geological profile shown on the Al-Nasiriya quadrangle (sheet NH-38-3), the boundary between Holocene deposits and Pleistocene deposits near Samawa is around Sea water level.

(a) Polygenetic deposits; Pleistocene – Holocene

It is restricted to desert plateau covering the Tertiary deposits. Lithologically, it is composed of unconsolidated admixture of sand, silt, clay and rock fragments. Its thickness does not exceed 1.0 meter.

(b) Gypcrete; Pleistocene – Holocene

It is developed around Sawa Lake on the western part of Samawa city, and forming the bank of the lake. It is considered as the oldest deposits of quaternary age and consists of secondary gypsum and gypiferous soil.

(c) Fluvial Deposits

1) Flood plain deposits:

They took place in different geomorphic facies, each of them has small variation in both geomorphologic position and geologic character. These facies are natural levees, crevasse splay and flood plain.

The flood plain deposits are contained in their upper part by irrigation channel deposits. The deposits are distributed all over the flood plain area except the southwestern desert area. They are laid down by the Euphrates and Al-Gharraf rivers.

The processes of flood are held by means of main channel of Euphrates River, distributaries and network of irrigation channels.

a) natural levees

They are usually developed along both sides of courses of the Euphrates river and Shatt Al-Gharraf, in addition to remnants of many levees along ancient river courses, especially at the left bank of Tigris river.

The width of natural levees ranges between a few decades meters to one kilometer. Their height is one-two meters higher than the surroundings. They are built up of alternating layer (a few decimeter-0.5m) of fine sand, silt with less common silty clay. They may show laminations, cross bedding, and massive layering.

b) crevasse splay deposits

These are developed when the overbank flow (during flood) passes through a distinct channel across natural levee into certain relatively small basin. They are widely distributed near present rivers beside ancient ones.

The deposits are coarser grained than the associated natural levee. They consists of sand and silt with les common silty clay which increase towards the basin. The deposits are recent to sub recent in age.

c) flood plain deposits

These deposits cover wide area between natural levees at the basin of flood plain, forming flood plain system. They are contained by irrigation channel deposits. This is evidenced by the existence of coarse grained deposits in flood plain deposits.

Lithologically, the flood plain deposits are built up of silty clays, clayey silts, silts and sands. The silt and sand are more prevailingly in older layers of the flood plain.

The sands are fine to medium grained, grey to brown in color. They occur as thin or thick beds, rocks several meters. Massive, lenticular beddings and thin lamination are the most impressive sedimentary structures. The Euphrates flood plain contains high amount of hornblende and pyroxene with low amount of garnet and opaque minerals.

The silts are commonly clayey, they are of different colors, but mainly yellow and greenish grey. They reveal layering and are of lenticular character, alternated with other lithologic units. Lamination, banding and falser bedding are closely related to silts.

Silty clays are common in the superficial layers of the flood plain. Their colors are brown, reddish and grayish brown, brownish grey, yellowish and greenish. They are commonly massive, laminated due to color and variation of grain size. Weathered horizons are detected in Euphrates flood plain in the form of channels after plant roots, burrows, decayed plant roots, concentration of iron oxide and aggregation.

Generally the natural levee and crevasse splay deposits have less amount of salt than the floodplain deposits. The salt content increases towards the abandoned flood plains in the northern part of the project area, away from the present courses of the rivers.

(d) Lacustrine Deposits

1) Shallow depression deposits:

These types of deposits are concentrated in the east of Shatt Al-Gharraf and northern part of the project area.

The deposits are accumulated on the flood basin of Euphrates River and distributaries of Tigris River.

The deposits are characterized by fine texture, silty lays and clayey silts are most common lithologic constituents. They are grayish brown and greenish grey in color indicating stagnant or semi stagnant water environment. Mostly they are massive and aggregated, locally shows impressions of lamination and banding due to color changes and grain size variation. Salt content is relatively more than the flood plain deposits. Shells of mollusks are frequent at the surface, with humified plant roots.

Most of shallow depression deposits, in the area are dry, especially at the northern part, but it could be flooded by water during rainy seasons or flooding of rivers.

2) Marsh deposits:

The marsh deposits are of fine texture, consisting of silty clay and clayey silt. They are rich in carbonate fraction and humified organic materials. Greenish and bluish grey and black colors are dominant. The marshy beds are massive, rich in fauna.

Gradation of humification with depth is frequent. The humified black horizons (up to 0.5m in thickness), at the top of the marsh deposits grade to less humified horizons, indicated by greenish to bluish color (semi-marsh) and sometimes convert totally to fluvial deposits. Many species of fossils were detected,

The marsh system, according to Yacob, 1985 includes three main sub environments, these are marshes, fresh water lakes which are developed in the relatively deeper parts of the marsh (outside the area), brackish and saline lake which are characterized by sandy mud deposits.

3) Sabkha deposits:

This type of deposits is developed at the southwestern parts of the project area, near the border with desert area. The deposits are rather complex being affected by aquatic and aeolian sedimentation with intense surface evaporation.

(e) Aeolian Deposits

The deposits are developed out of the survey area, therefore, it is not distribute the survey area..

(f) Anthropogenic Deposits

This type of deposits include: ancient settlements and sites- tells, irrigation canal bodies and other remnant of man activity. They are distributed all over the area and mainly concentrated on the abandoned flood plains indicating dense inhabitant during late historical periods.

Lithologically, the deposits consist of fine clastics of different origin, mixed occasionally with ancient brick and pottery fragments.

Upon such geological background, soil Investigation for Electrical Gas Turbine Power Plant project was carried out.

5.2 Investigation on Nasiryah Project Site

The Study Team employed and entrusted a local consultant to carry out the following investigation on Nasiryah II Project Site as per the scope of work mentioned below:.

5.2.1 Investigation Plan

(1) Reconnaissance

(a) Available maps and topographical data
(b) General topographical feature of survey area
(c) Photographs of survey area, access road, bridges, obstructions, etc.
(d) Investigation on transportation route from trunk road to survey area including investigation on the carrying capacity of existing bridges and embankment
(e) Hydrographical condition of survey area such as storm water drainage and flood condition
(f) Existing survey monuments or bench marks

(2) Topographical survey for plant area

(a) Establishment of bench marks: Coordinates and elevation of the indicator rod on the bench marks shall be established with National Grid system. Bench marks shall be protected with appropriate enclosure against damage by traffic, etc. The specification of bench marks shall be proposed by the Subcontractor and approved by the Purchaser before the installation work.
(b) Installation of boundary stakes: The location and specification of the boundary stakes shall be proposed by the Subcontractor and approved by the Purchaser before installation work.
(c) Topographic survey in the plant area with leveling survey at intervals of 10m grid.
(d) River bank profile (if the site is along a river) shall be indicated. Maximum and minimum water level shall be surveyed.
(e) Report: the report shall include;
1) title of the work
2) survey area, date, name of surveyor
3) weather
4) equipment used
5) general condition of the site and existing maps
6) field data sheets
7) calculation sheets
8) photographs,
9) maps (1/1000 scale) with 0.5m contour lines
10) digital terrain model (AUTOCAD or equivalent); All measuring points with elevation shall be indicated in 3D model. All contour lines shall have the height data in 3D model.

(3) River bathymetric survey

(a) Topographic survey of the river configuration and/or shoreline shall be conducted by means of traversing, plane-table surveying and leveling.
(b) Bathymetric survey shall be conducted with lead sounding.
(c) Grids of sounding shall be developed through the surveying area at intervals of 50m (for river section), 50m (for river axis).
(d) Control points for bathymetric survey shall be set out by traversing and leveling, and the location of sounding shall be confirmed by method of intersection and/or three-point method.
(e) Water level shall be observed at least once in every half hour while the sounding is performed, and the sounding record shall be corrected in accordance with fluctuation of water level, if any.
(f) Report: the report shall include;
1) title of the work

2) survey area, date, name of surveyor
3) weather
4) equipment used
5) general condition of the site and existing charts
6) field data sheets
7) calculation sheets
8) photographs,
9) maps (1/1000 scale) with 0.5m contour lines
10) cross-section and transversal profile shall indicate No. of control points, total distance from start point, ground elevation at each surveyed point, water level during the surveying work. The scale of the drawing is;
- Cross-section: 1/200
- Transversal profile: 1/500

vertical scale may be changed (exaggerated) as appropriate

(g) digital terrain model (AUTOCAD or equivalent); Elevation of all measuring points shall be made in 3D model (All contour lines shall have the height data in 3D model)

(4) Hydrographic survey

(a) Historical hydrographic data collection & analysis

Historical data collection and analysis (Water level, Water temperature, Water discharge flow, Water flow velocity, Historical flood, Chemical analysis of river water) on the candidate site or gauging station near the candidate site

(b) Hydrographic survey

Water level, Water temperature, Water discharge flow, Water flow velocity, Material analysis of Riverbed soil

(5) Geological survey

The Study Team carries out soil investigation to get the necessary information for design of the Power Plant facilities and buildings, especially to investigate the characteristics of foundation strata.

Table 5-2-1 Geological survey works

	Field Works (5 numbers boreholes)
A1	Mobilization and demobilization
A2	Installation of boring equipment at each drilling points, moving included
A3	Rotary drilling
A4	Undisturbed sampling of cohesive soils in borehole
A5	Standard Penetration Test (SPT) accompanied by photograph of each soil sample in a split barrel
A6	Groundwater measurement at each borehole
A7	Groundwater sampling at each borehole
	Laboratory Works
B1	Grain size analysis (sieve test, hydrometric or sedimentation)
B2	Specific gravity
B3	Total unit weight / Bulk Density
B4	Natural Moisture Content
B5	Liquid Limit and Plastic Limit
B6	Consolidation test
B7	Triaxial Test
B8	Compaction test
B9	Chemical tests on soils
B10	Chemical tests on ground water
B11	Reporting

(6) Environmental baseline survey

(a) Ambient air quality [PM10, SPM, SOx, NOx, CO]

- Ambient air quality will be measured at Total two (2) sampling points. Detailed sampling points will be discussed with JICA Study Team. The chemical analyses should apply to the method specified in the environmental standards in the IRAQ.

(b) Ambient water quality [pH, SS, Oil & Grease, Cl_2, Cr, Cu, Fe, Zn, Pb, Cd, Hg, As, Ca, Ammonia, Temperature.(Upper & Lower layer), TDS, BOD5, COD, NO_3, SO_4, Mg, SiO_2, P, Salinity]

- Ambient water quality will be measured at Total 2 sampling points at River in front of the project site. Detailed sampling points will be discussed with JICA Study Team. Water for analysis will be collected from the surface water of the river by a bucket. The chemical analyses should apply to the method specified in the environmental standards in the IRAQ.

(c) Noise

- Ambient noise level will be measured at Total two (2) sampling points. Detailed sampling points will be discussed with JICA Study Team. The data collection should be done for 24 consecutive hours. The measurement method should apply to the method specified in the environmental standards in the IRAQ.

(d) Vibration

- Ambient noise level will be measured at Total two (2) sampling points. Detailed sampling points will be discussed with JICA Study Team. The data collection should be done for 24 consecutive hours. The measurement method should apply to the method specified in the environmental standards in the IRAQ.

(7) Layout of investigation works

The Study Team and the Iraqi Team agreed to expand the site area of 300m to the east. According to this agreement two (2) boreholes were shifted 150m to the east. Figure 5-2-1 shows the revised FS site investigation works plan.

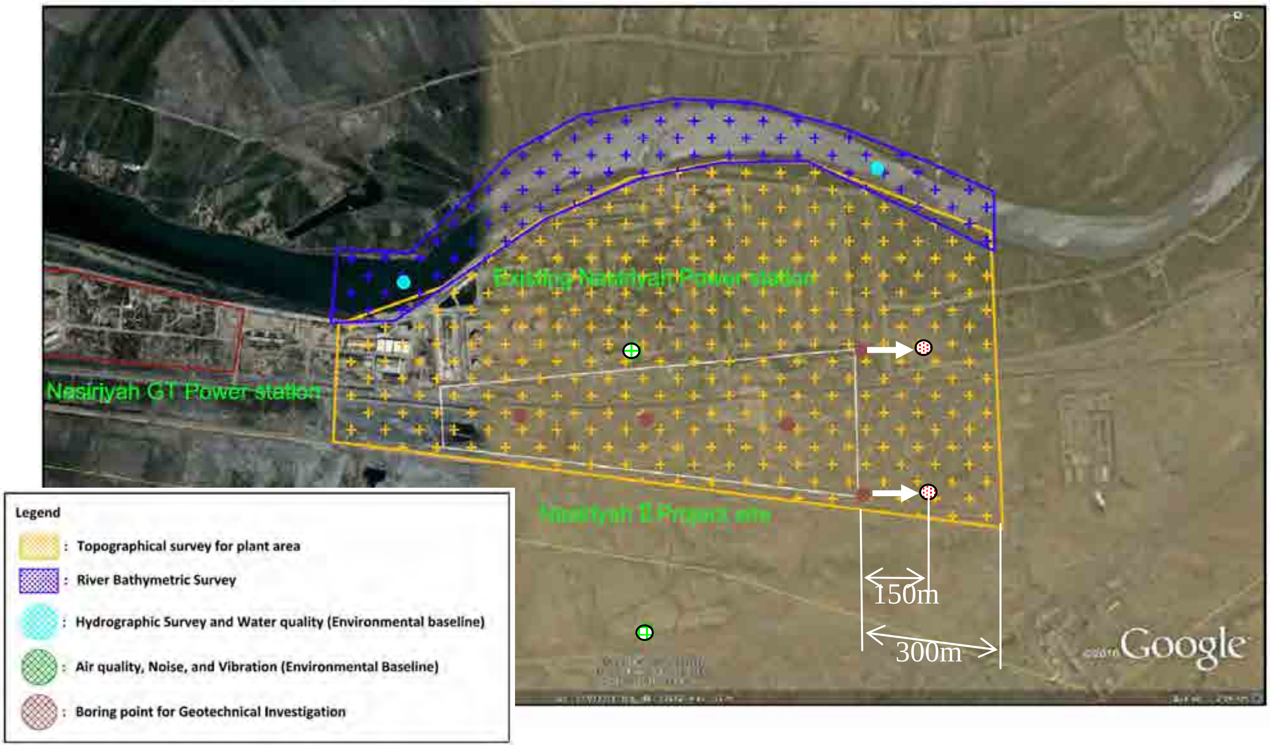


Figure 5-2-1 Revised FS Site Investigation Plan

5.2.2 Investigation Results

(1) Reconnaissance

The Project site is located approximately 340 km southeast from Baghdad.

The project site is situated the right bank approximately 7 km of upstream to the Euphrates River from Nasiryah City, and is bordered as follows;

North:	Primary road No.7, further the existing Nasiryah thermal power plant, Euphrates River
South:	The railway from Baghdad to Basra
East:	Open space
West:	400kV Transmission Line

There are some objects in the project site and near the primary road No.7

・200V electric distribution line on the side of the road
・West side of the road is intersecting with 400kV transmission line
・Several buildings, communication towers and many palm groves on both sides of the road
・Water canal near north side of the road with width of approximately 5 meters
・Many bush in the project site

(a) Power station: the power station dominates about half of the surveying area, where the Euphrates River is passing beside its northern side.
(b) Euphrates River: the river passes the northern side of the station, there are no features to be considered such as bridges or canals pass in the surveying area.
(c) Railway road: the rail road is passing in parallel to the southern side of the surveying area and it’s currently used for Cargo and passengers transportation and its branching to sub-branch toward the power station and this branch currently is out of function.
(d) Cars park: the cars park is located in front of the entrance of the power station
(e) Concrete casts: There are foundations of concrete factory located in the southern side of the power station in the open area of surveying.
(f) Minor road: minor road is dividing the surveying area in to two parts, northern (power station) and southern (open area), the road width is about 7m.
(g) There are no main features on the road such as bridges, canal.

(2) Topographical survey for plant area

Topographic survey has been conducted and the topographic map of the project site area has been completed as drawing “Topographic Map” in Attachment - 3.

Project site: EL+2.7m to +6.9m (approximately average EL+4.0m)
Existing Power Plant
Tank Area: approximately EL+6.0m Oil-proof embankment EL+7.8m
Power Block: approximately EL +6.0m
Switch yard: approximately between EL+6.0m and EL6.3m
C/T System area: approximately EL+6.0m
Euphrates River Embankment approximately between EL+7.0 and +8.8m
South side Main road of Existing Power plant: approximately EL=+6.0m
Rail way : approximately EL+ 6.0m
West side embankment of Existing Switchyard: approximately EL+7.0m

(3) Hydrographic survey

Euphrates River is one of the most important rivers in West-Asia. It flows from the mountains area in the south east of Turkey, it's the result of two branches combination.

Euphrates River leaves the Turkish territories and enter to Syria at Grables town, it keep flows in Syria and meet his other branches until reaching the Iraqi borders, it cross the Iraq borders at Hosaiba town in the north west of Iraq, about 170 meter over sea level.

During his trip from the Turkish land to the Iraqi land, a lot of storage project has been made on it. About 22 dams in GAP project in turkey, in addition to Altabaka dam, Al baath dam, and Teshreen dam in Syria. These dams give Turkey and Syria the ability to control about 80% of the river water flow.

The river enter Dhi-Qar governorate at Al-Beteha town, 36 Km to the north of Nasiryah city, after crossing 920 km in the Iraqi land before entering Nasiryah city. It could be said that this location present its sunset Geomorphology cycle because of the decreasing in the river surface slope (2.7cm/km) and the increasing in river section.

The river continue in his flow and enter Sooq Al Sheokh at the coordinate (N 36°58'30.64" E30°89'46.28") 25 km to the south of Nasiryah where two branch break from it, several weirs has made to control the river water flow and level.

Figure 5-2-2 Euphrates River

(a) Result of Hydrographic survey

The result of Hydrographic survey is shown as follows;

Table 5-2-2 Result of Hydrographic survey (H1 point)

Point Name	Date &Time	Mean Velocity (m/sec)	Max. Velocity (m/sec)	Max. Depth (m)	Mean Depth (m)	Width (m)	Area (m^2)	Discharge (m^3/sec)	Water level (m)	Water temp. (ºC)
H1	4/10/2011 at 12:15	0.26	1.28	3.91	3.03	127.9	387.7	101	3.8	28

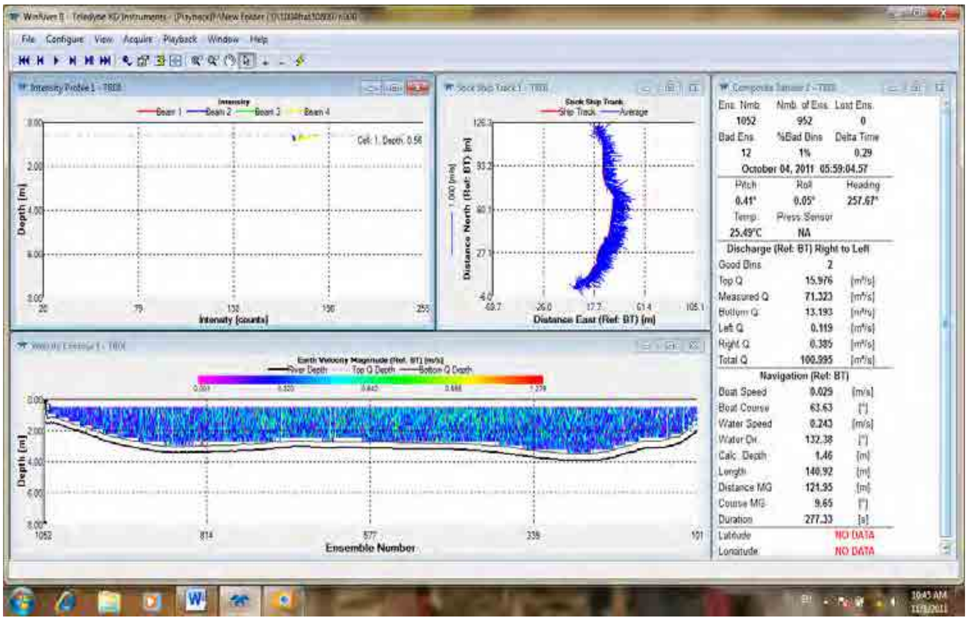


Figure 5-2-3 Result of Hydrographic survey (H1 point)

Table 5-2-3 Result of Hydrographic survey (H2 point)

Point Name	Date &Time	Mean Velocity (m/sec)	Max. Velocity (m/sec)	Max. Depth (m)	Mean Depth (m)	Width (m)	Area (m^2)	Discharge (m^3/sec)	Water level (m)	Water temp. (ºC)
H2	4/10/2011 at10:45	0.249	1.44	5.06	3.67	103.3	414.1	103	3.8	28 c

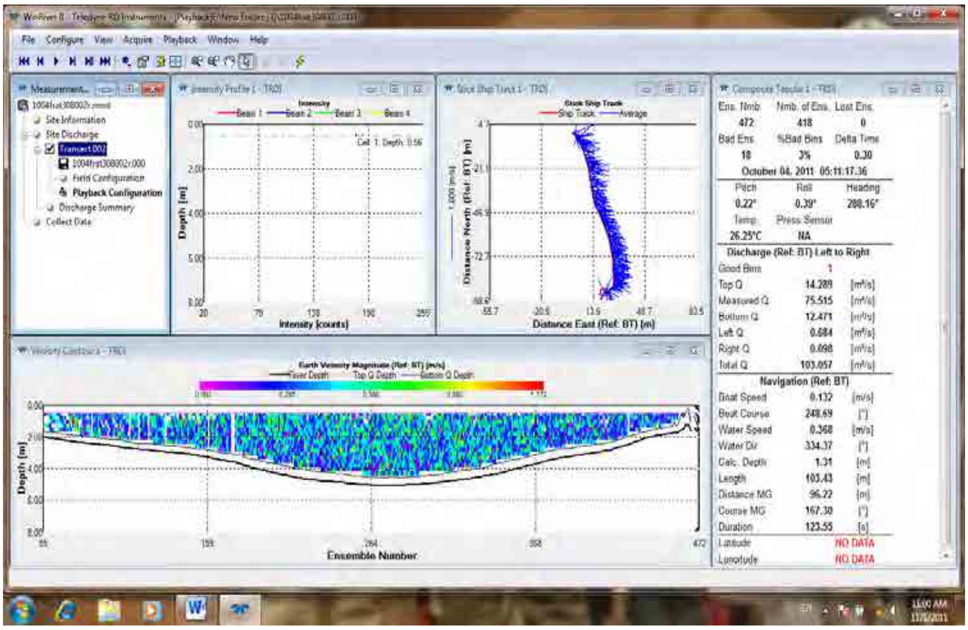


Figure 5-2-4 Result of Hydrographic survey (H2 point)

(b) Chemical Analysis for River Bed

Riverbed soil samples collected from both sampling locations were chemically analyzed in the laboratory according to British Standard (BS 1377-3:1990), Table 5-2-4 Demonstrate the chemical analysis results of both samples.

Table 5-2-4 Chemical Analysis for Euphrates River Bed

Ref.	Type of test	H1	H2	BS 1377-3:1990
1	Conductivity	347 ms/ cm	364 ms / cm	>1000 ms/cm
2	Total solids	273 ppm	294 ppm	>1000 ppm
3	Saliently	0.0	0.0	--
4	Inorganic material	542 ppm	493 ppm	>3000 ppm
5	T.D.S	348 ppm	365 ppm	>1000 ppm
6	PH	8.28	8.32	--
7	SO3 %	179 ppm	188 ppm	>1000ppm
8	Gibbs	384.8 ppm	404.2 ppm	>1000 ppm
9	Cl chloride	293 ppm	304 ppm	>1000 ppm
10	HCO3 , CO3	400 ppm	335 ppm	>1000 ppm
11	Ca	3.8	4.0	--
12	Mg	5	4.9	--
13	Organic material	10 %	9.94 %	>10%

Considerations & results are as listed below:-

1) PH: acetic function: it is used to classify the soil type and its elements, after testing; the result was basic where a lot of carbonate is available.
2) Conductivity: it represents number of free ions released from dissolved salt in soil by water, test results showed acceptable range (smaller than 1000 ms/cm).
3) Total suspended solid (TSS): represent the suspended material in the solution, test results showed acceptable rang (smaller than 1000 ppm).
4) Salinity: represent the saline in soil, test result showed no saline in soil.
5) Inorganic material: includes Inorganic ions released from dissolved and non dissolved salt in water.
6) TDS, total dissolved solid: represent the total dissolved solid in water, test results showed acceptable rang (smaller than 1000 pm).
7) Gibbs: represent the percentage of hydro calcium sulphate, test results showed acceptable rang (smaller than 1000 ppm).
8) Carbonate and bicarbonate (CO3, HCO3): test results showed acceptable rang (smaller than 1000 ppm).
9) Calcium and magnesium: represent the percentage of Alkalis in soil.
10) Chlorides: represent the percentage of chlorides in soil, test results showed acceptable rang (smaller than 1000 ppm).
11) Organic material: represent the percentage of harmful organic material in soil, test results showed acceptable rang (smaller than 10 %).

(c) Historical Data

Euphrates River Data were measured for past years at Dhi-Qar.

The date collected was for the nearest measuring station to the Nasiryah Power plant It is located beside Al Nasser bridge about 4.3 Km to project site with the coordinates of N= 31, 02‘, 37.00” E =46, 14‘, 35.71” as shown in Fig 5-2-5.

Figure 5-2-5 Euphrates River measuring point (at Al Nasser Bridge)

1) Historical flood of Euphrates River

It is clear from the historical average discharge for the period (1950-1997) collected from National Center for Water Resources Management (NCWRM) that the years 1950, 1967, 1968, 1969 witness flood where the monthly average discharge exceeded 1400 m^3/s but unfortunately there is no records found for the water level in these years, the only recorded data was obtained from Ministry of Water Resource (MOWR) for the flood of 1988 as follows:

Table 5-2-5 Historical flood of Euphrates River

Date of flood	Level of Euphrates(m)	Measured discharge (m^3)
27 June 1988	6.3	1514

2) River Water Level and River Flow Rate

Figure 5-2-6 shows the Euphrates River monthly mean flow rate at Al Nasser Bridge in 1950 to 2011.

Basically, the maximum river flow rate appears in every May and the minimum river flow rate appears in every August or September. During the observation period, the maximum record of the river flow rate is 1,400m3/sec in 1950 to 1955.

The River flow rate has gradually decreased as a whole. In addition, no typical peak season in flooding has been observed recently and therefore the flow rate has been levelized through the year.

The tendency of declines of River flow rate has continued in the past two decades. In 1991 to 1997, the flow rate was eventually decreased by approximately 200m^3/sec as a yearly average. In 2007, the maximum river flow rate is reduced by approximately 100m^3/sec, and the minimum flow rate is recorded at approximately 10.2m^3/sec in November 2009.

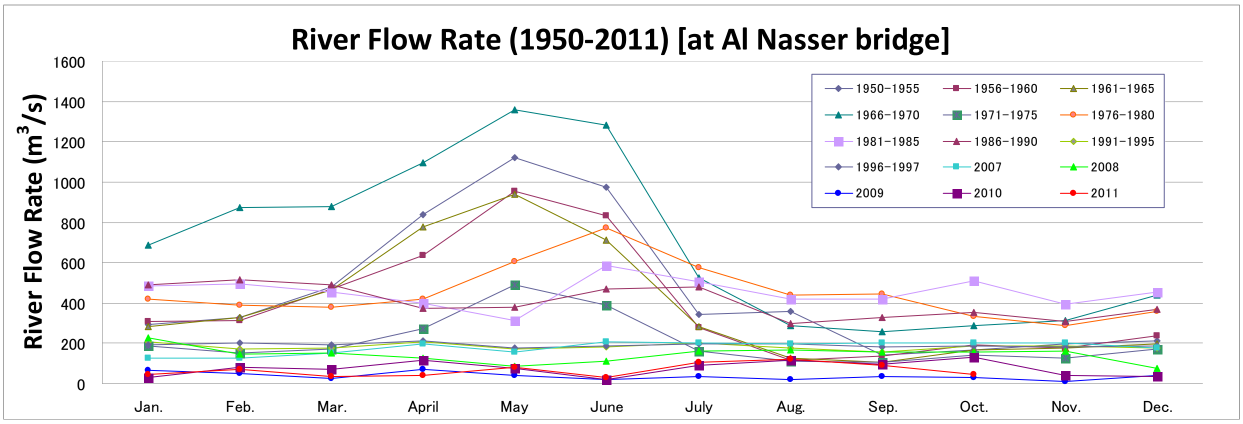


Figure 5-2-6 Euphrates River Flow Rate (1950-2011) (at Al Nasser Bridge)

Figure 5-2-7 shows changes of the daily average of water level at Al Nasser Bridge between 1987 and 2011. The water level does not have any typical seasonalities. But significant declines have happen on the year-on-year basis. The water level has shrunk by half of the level recorded in early 1990s.

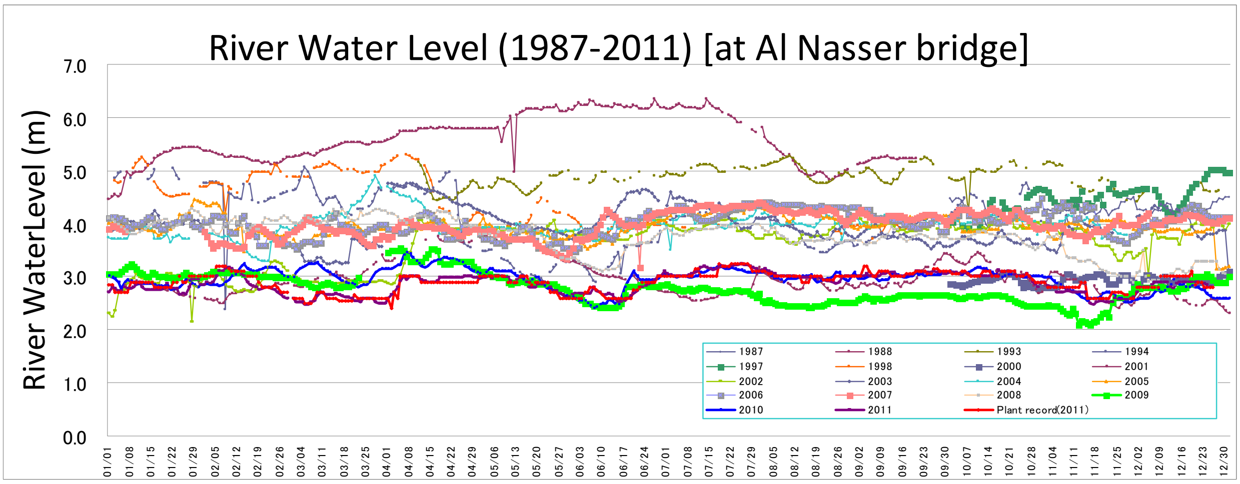


Figure 5-2-7 Euphrates River Water Level (1987-2011) (at Al Nasser Bridge)

Figure-5-2-8 illustrates changes on monthly average basis of both water level and flow rate of Euphrates River in 1987 thru 2011. A remarkable decline of river water flow has been observed through the past two decades. The reason is why a number of projects for water resource development have been developed in the upstream of Euphrates River. Even though there are many projects domestically such as irrigation, drinking water, and hydropower generation, the significant effect to reduce the river flow is caused by impoundment at dams in the upriver countries such as Turkey. After 2009 when Turkey has completed construction of its new dam, the water flow of Euphrates River was remarkably decreased and recorded the minimum flow rate at 10.2 m3/sec.

Assuming a CCTPP has 1,800MW generation capacity, in general, the once-through cooling system requires around 45~60m3/s water flow while the wet cooling tower system requires about 1.0m3/sec water flow. A one-through cooling system is the first choice, provided that plenty of water is economically available near the site. Under the river water condition mentioned above, the once-through cooling system is unlikely to work through the most part of the year particularly in the dry season. In fact, Iraqi water resource authority has forbidden adopting it as steam turbine condenser cooling. Therefore, MOE had changed its design philosophy where new thermal power projects need to select alternatives other than once-through cooling.

Meanwhile, a wet cooling tower plant is supposed to be the second choice. Its water volume requirement is expected about 1.0m3/sec accounting for 10% of the lowest flow rate of Euphrates River. Significant impacts are projected in terms of downstream water use and environment even if a wet cooling tower plant is installed to the project.

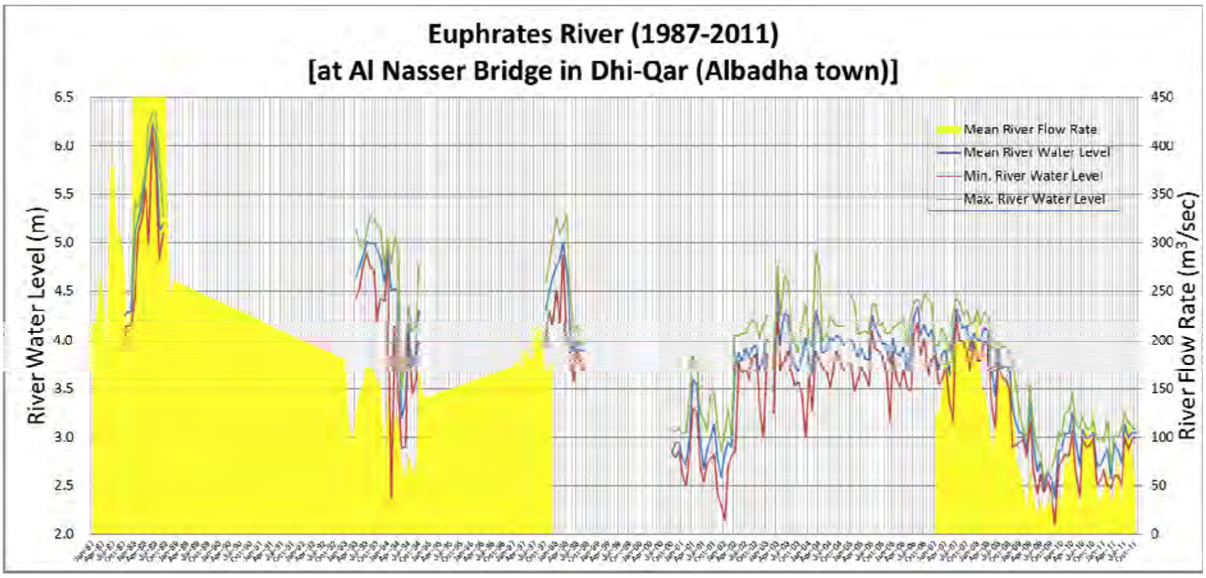


Figure 5-2-8 Euphrates River Water Level and Flow Rate (1987-2011) (at Al Nasser Bridge)

Iraqi water resource authority, MOWR, has released its strategy paper on national water resource development. The paper is namely ‘A five-year Plan from 2010 to 2014’ summarized in Table 5-2-6. It made it clear that a remarkable decline of Euphrates and Tigris river discharges did occur and is further expected in light of the multi-purpose water use. It also pointed out that a countrywide strategy is needed for appropriate resource allocation. Degradation of river water quality has been also progressive due to continuing to discharge drainage water to the rivers. The Iraqi government has planned the outfall drainage projects to convert the drainage water directly to Gulf. Therefore, it is likely that waste water disposal to the rivers should be more strictly regulated.

Table 5-2-6 Average annual river inflow to Euphrates and Tigris Rivers at the borders[13]

Annual River Inflow Average at the borders	Until 1989	1990-2005	Until 2014 (Planned)
Euphrates River	27.4 BCM	17.4 BCM	8.5 BCM
Tigris River	N.A.	19.4 BCM	9.2 BCM

BCM = billion cubic meters, NA = not available

As implications from the status of degradation of river water quantities and qualities, the JICA Study Team and MOE Team have agreed upon application of a design philosophy of "least water consumption and least waste water discharge" for the designing of power plant facilities, particularly cooling facility.

(4) River bathymetric survey

The result of river bathymetric survey around project site is show in Attachment - 4.
River width is approximately 100m, minimum riverbed level is -7.7m.

(5) Geological survey

As an essential requirement for the study of this important project, Soil Investigation of project site is required to explore the subsoil conditions of the site to facilitate and evaluate the foundation design.

- Geotechnical Boreholes (diameter more than 86mm), totally five (5) boreholes.
- Depth should be subjected to the results of Standard Penetration Test (SPT) and at least 25m for each hole.
- SPT by ASTM 1586 or JIS A 1219 basically at every 1 m except for undisturbed sampling depth.
- The test should be conducted until N-values of more than 50 are stacked at least five times in continuous state.
- Undisturbed samplings with Fixed piston type thin-walled sampler or Denison type sample by ASTM D1587 (for cohesive soils)
- Groundwater measurement at each borehole after completion of drilling works
- Laboratory tests

[13] The Preparatory Survey on South Jazira Irrigation Project in Republic of Iraq (JICA, 2011)

A general site plan indicating the location of the boreholes is in the Figure 5-2-9 shown below.

Figure 5-2-9　General Plan of geological and hydrological investigations

(a) Soil Exploration and in-situ tests

The location of boreholes is shown in the Figure 5-2-10, and the elevation of the boreholes is shown in the Table 5-2-7 shown below:

Figure 5-2-10　General Plan of Boreholes

Table 5-2-7 Elevation and coordinate of five bore-holes

Borehole No.	Elevation (m)	latitude	Longitude
B1	3.458	31° 2′ 1.00″ N	46° 11′ 20.19″ E
B2	4.905	31° 2′ 0.02″ N	46° 11′ 39.66″ E
B3	4.982	31° 1′ 59.28″ N	46° 11′ 54.19″ E
B4	5.625	31° 2′ 6.93″ N	46° 12′ 6.07″ E
B5	3.738	31° 1′ 56.38″ N	46° 12′ 6.07″ E

(b) Description of Subsoil Strata

The subsoil strata at the site which explored by five (5) boreholes at thirty (30) m depth consist mainly from a major stratum namely; medium, stiff to very stiff grayish brown to greenish gray and other color appearances differs from borehole to another as detailed in the boreholes logs attached hereinafter, fat Silty CLAY, inter-bedded by loose, medium dense to very dense fine grained Silty SAND layers at various depths throughout the boreholes.

Lots of white shiny traces of soluble salts and black spots and/or lines of organic matter together with red rusty brown traces of iron oxide compound and white crystal pieces of mica mineral compound intervened within the strata.

The Clay and Sand fractions in certain cases were high in amount to the extent where the description of the layers altered to Clayey Silty SAND and Sandy Silty CLAY consequently.

From the values of specific gravity, consistency indices, passing #200 sieves and according to the Unified Soil Classification System (USCS), the majority of the Silty Clayey soil is classified as CH and MH, i.e. Silty Clayey soil with high plasticity, while the Sandy soil layer is classified as SM and SC.

The water table was encountered, as observed during the time of exploration at a level in the wide range of 1.0-2.0m, below the existing natural ground level.

Geological profiles along the boreholes are drawn in the Figure 5-2-11.

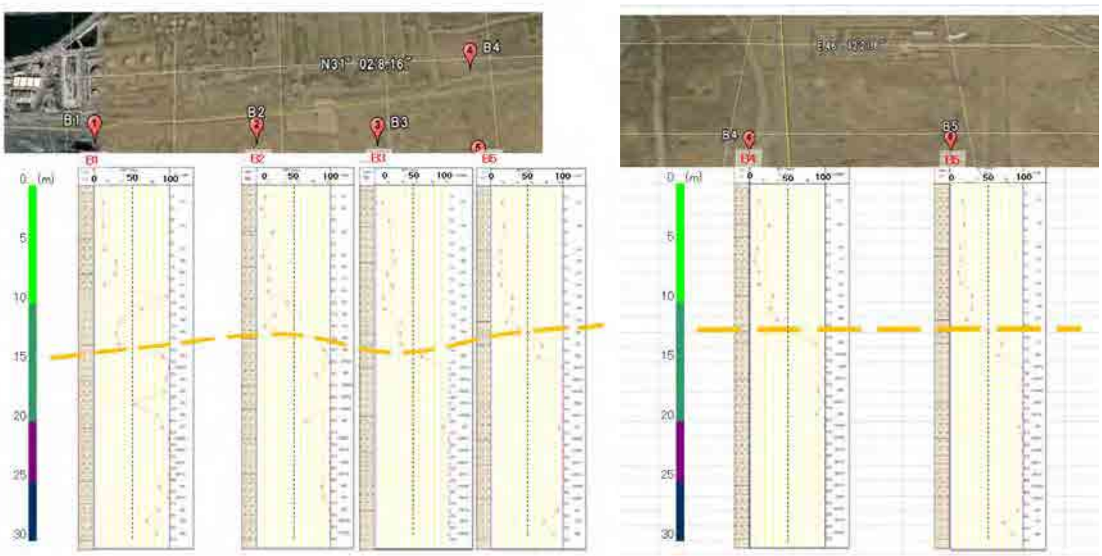


Figure 5-2-11 Geological profile along the boreholes (Left; W-E, Right; N-S)

(c) Discussion of Results

A discussion of the results which were derived from field and laboratory testing carried out on site is as follows:-

The site subsoil consists mainly of deposits of Silty CLAY strata. The major strata shows, medium to stiff in consistency, organic matters and soluble salts are frequently intervened in the strata.

The water table was encountered, as observed at the time of exploration.

The fluctuation of water table with the seasons could be observed (rising during spring). The zone immediately above water table is greatly affected as far as strength and compressibility are concerned. As moisture increases, the strength decreases and compressibility increases.

The saturated soil condition below the water table makes the problem of settlement significant as consolidation is process of graduated decrease of the water content from saturated soil under constant load.

Settlement of structures is governed by imposed loads and soil response to load and change in environment. As such, the settlement computations need to be considered in design.

Due to presence of soluble salts materials associated with the presence of the water table in the encountered strata at the site in question, that will increase the problems of leaching and enhance the collapse tendency, special precaution should be taken into consideration.

Soluble salts materials are water soluble and it dissolves when water table fluctuates or when water infiltrates into soil stratification causing loss of cementation.

Following precautions for protecting from settlement problem should be taken into consideration:

1) Using efficient drainage and water discharge system for rain water away from footing zone.
2) All concrete work in contact with soil should be coated with bituminous emulsion material that meets the Iraqi standards requirements (IS 1173/1988) in three (3) layers.
3) Pipes should be well fixed and laid then covered all around with permeable filter material to avoid any leakage problem.

The results of swelling characteristics of soil were evaluated from odometer consolidation device shows that the soil have moderate tendency to swell of about 10-25 kPa.

In general, to avoid problems associated with foundation works on such a soil, two (2) provisions are usually considered:

- Making the structure resistant to damage from soil movement by strengthening the structure to withstand movement, or
- Through compacting, the top soil layer and/or the zone beneath the base of footing after the excavation work.

Also, in order to ensure the durability of the foundation in the long term, the following points must be well-considered and thoroughly paid attention in the design process:

1) A factor of safety equal to three (3) is adopted for all calculations of bearing capacity formulae which is acceptable value.
2) Spreading a layer of well compacted sub-base according to the specification with enough thickness of about 0.5 to 1.0 m should be placed beneath the base of foundation to make even and adjust any irregularity occurred during excavation.
3) One of the most practical and economical methods is through the use of compaction control for the backfill of the zone around the foundation after being laid, with well compacted clayey layer of low permeability.

(d) Engineering Geological Assessment

1) The heavy structures with load stress exceeds the allowable bearing capacity, should be supported on piled foundation with tip of piles of resting at 13 to 15 m below ground surface.
2) Shallow foundation (spread, strip and continuous footing) could be used for light weight structures

provided that the applied load stress does not exceed the allowable bearing capacity.

3) A layer of well compacted sub-base according to the specification with thickness of 0.5-1.0 m should be placed beneath the base of shallow foundations for structures under dynamic load like Turbines, while for the single and double story buildings the thickness of the layer would be 0.3 m, to make even and adjust any irregularity occurred due to excavation, with following requirement:
   a) The value of CBR not less than 45% (ASTM D-1883) at 95% of the max dry density established according to ASTM D1557
   b) Liquid limit 25 % maximum
   c) Plasticity index 6 % maximum
   d) Organic matter not more than 2 %
   e) SO_3 not more than 2 %
   f) Total soluble salts not more than 5 %
   g) Gypsum content not more than 5 %
   h) Relative compaction not less than 95 % modified

4) The depth of the foundation could be at 1.0 m for the buildings composed of single and double story with the condition of laying 0.3 m thick compacted sub-base (type B) layer having relative compaction not less than 95% of the maximum dry density evaluated from the laboratory Modified Proctor test. The compacted sub-base layer shall extend at least 10 cm from the foundation edges.
5) The ground must be sloped away from structures as much as possible and those slope maintained so that runoff water will be carried away of close foundations, but must be drained into lined ditches.
6) Soil materials for embankment shall be transported from a borrow site distant around 10 km from the site. Tested result of the soil is shown in Table 5-2-8 and is drawn in Figure 5-2-12. Actually, the soil has no sufficient quality for the requirement.

Table 5-2-8 Tested result of soil to be used for embankment

Test [14]	Value	Required quality
Maximum Dry Density	1.77	1.7 (g/cm³) Minimum
Optimum Moisture Content	19.00	- - -
Liquid Limit	40.00	55.00% Maximum
Plasticity Index	12.00	30.00% Maximum
CBR	10.5	4.00% Minimum
Percentage of remaining materials on #200 (0.075 mm) sieves	13	20.00% Maximum
Uniformity coefficient	6.67	≧10
Gradation coefficient	1.67	Close to 1.0
Sand content (%)	13	fine components rate should be less than 20%
Silt content (%)	22	
clay content (%)	65	

[14] The test was proceeded in accordance with SORB for Year 2011 by Basra University Engineering Faculty Soil and Road Laboratory

-

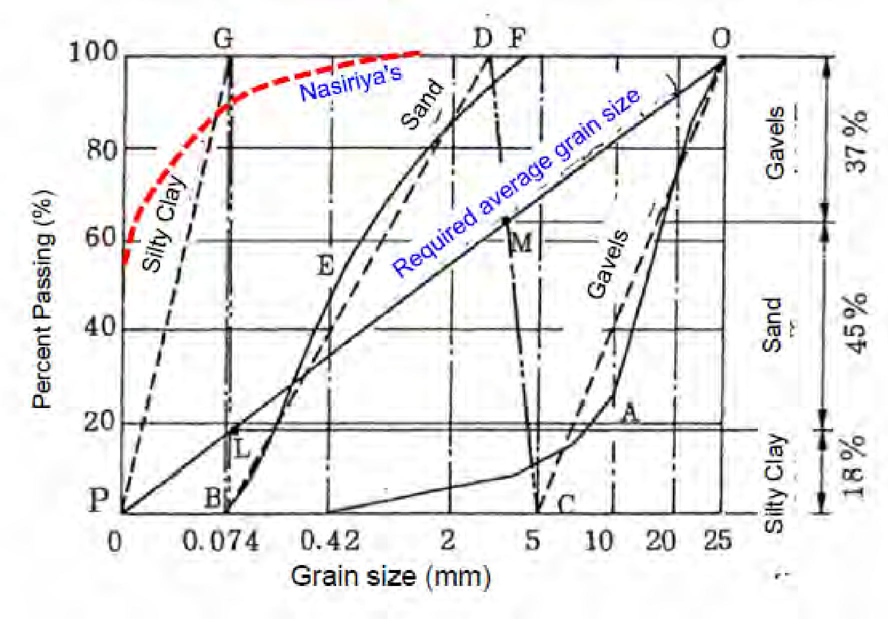


Figure 5-2-12 Grain size distribution of tested soil for embankment

7) In case the total soil volume which should be embanked is 1,000,000m3(50ha*2m), it is estimated totally 800-900 times/day (200 times/day*4 rounds, 300 times/day*3rounds) is required in a half year, therefore, it is not the best plan to find and bring sandy material even if the soil has sufficient quality for the requirement. Improvement of the supplied clayey soil may be rather better than sand which might be transported from some distant places.

(6) Environmental baseline survey

The Environmental baseline survey was conducted from 26 to 28 September 2011 at the sites indicated in Figure 5-2-13; E1 and E2 for ambient air quality, noise and vibration surveys, and H1 and H2 for ambient water quality survey. Regarding the standard in each survey field, refer to “5.4.2 Legislation and Standards”.

Table 5-2-9 shows the dates ad the field works of the survey.

Table 5-2-9 Survey schedule

Date	Field works
26 September 2011	Collecting river water samples
27 September 2011	1. Collecting air samples 2. Noise and vibration measurements
28 September 2011	Continuation of noise and vibration measurements

The result of each survey is described in the following sections.

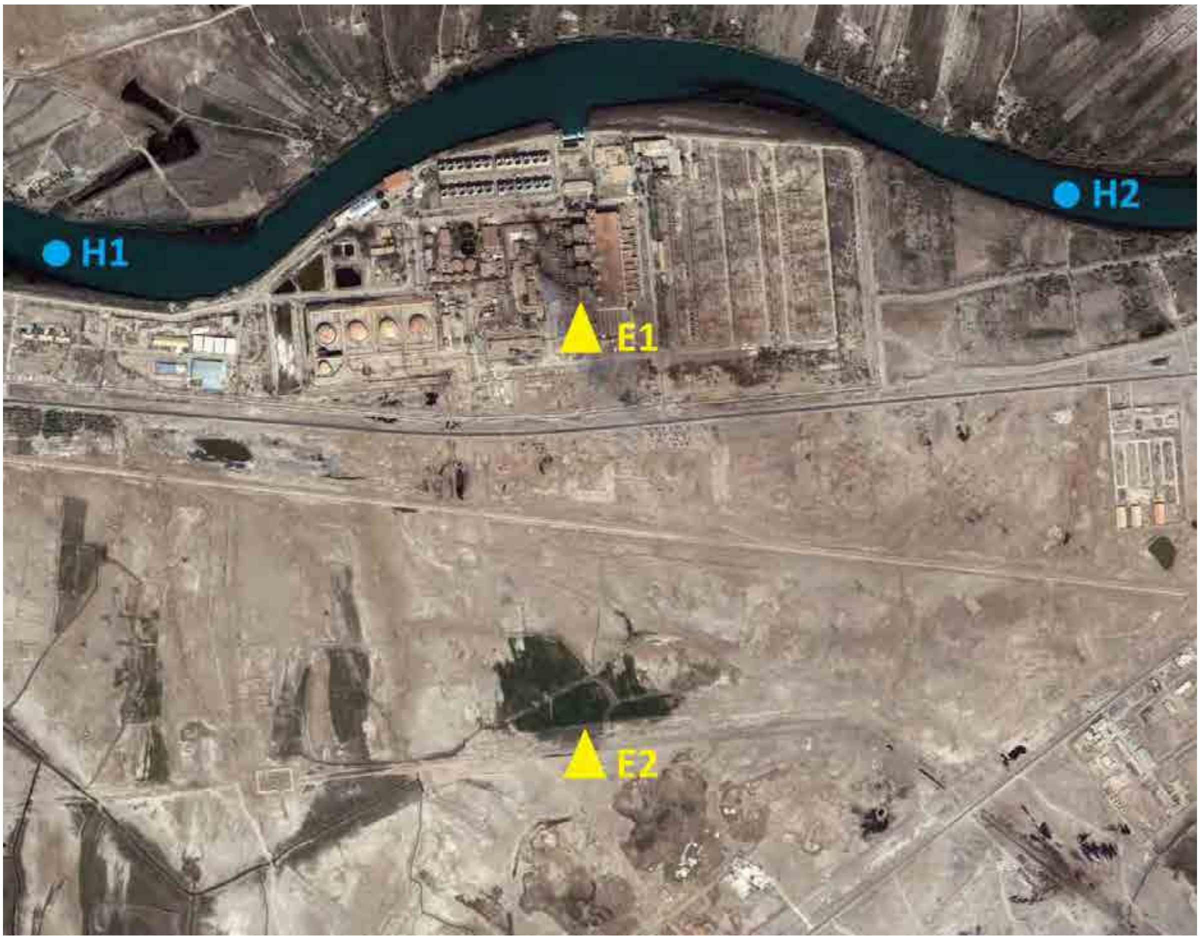


Figure 5-2-13 Sampling sites for Environmental baseline survey

(a) Ambient air quality

Ambient air quality was measured at the sampling points (E1 and E2 in Figure 5-2-13). The measured items are SPM, PM10, CO, NOx and SOx.

In order to undertake the field work for air quality study different field devices and equipments had been used for this investigation. These devices have been prepared and calibrated are:

- Low volume air sampler for the collection of SPM from the air.
- Temperature and relative humidity device, Lutron-HT-301SAA, Taiwan, for the (temperature ºC) and (relative humidity: RH %) measurements.
- Wind speed device, Meteo Digit, type 916, Germany, for wind speed measurements.
- Full computerized light microscope, type Nikon Eclipse- model ME600, with very high resolution for determining the characterization of particle morphology, type, and size diameter of the suspended particulate matter have been used.
- Other devices for gas concentration measurements, gas analyzers have been used for the measurements: gas analyzer TSI Model 8762 (made in USA) for CO and CO_2; and gas analyzer MultiRAE Plus (made in USA) for SOx and NOx.

The result of the survey is summarized in Table 5-2-10 and Table 5-2-11.

Table 5-2-10 Ambient air quality (E1)

Air pollutants	Time of sampling			Iraqi Standards Unit: μg/m^3
	9:45 AM	3:00 PM	5:30 PM	
SPM (μg/m^3)	4076.18	3107.71	3252.68	-
PM_{10} (μg/m^3)	1019.04	776.93	813.17	350μg/m^3/24 hr
CO (ppm)	47.6	23.7	61.5	35 ppm/hr
CO_2(ppm)	316	320	303	-
NO_2 (ppm)	4.7	0	0	0.04 ppm/hr
SO_2 (ppm)	0	0	0	0.1 ppm/hr
Meteorological measurements				
Temp. (°C)	46.4	46.8	40.3	
RH%	17.2	21.4	19.1	
Wind speed (m/s)	0.1	0.3	0.1	
Wind Direction	NW-SE	NW-SE	NW-SE	

Table 5-2-11 Ambient air quality (E2)

Air pollutants	Time of sampling			Iraqi Standards Unit: μg/m^3
	12:30 PM	5:00 PM	6:30 PM	
SPM (μg/m^3)	3514.48	3254.50	3326.76	-
PM_{10} (μg/m^3)	880.52	813.62	830.69	350μg/m^3/24 hr
CO (ppm)	44.5	70	37.3	35 ppm/hr
CO_2(ppm)	316	320	303	-
NO_2 (ppm)	0	0	0	0.04 ppm/hr
SO_2 (ppm)	1.0	0	0	0.1 ppm/hr
Meteorological measurements				
Temp. (°C)	47.5	44.2	37.8	
RH%	15.3	18.0	20.0	
Wind speed (m/s)	0.4	0.3	0.3	
Wind Direction	NW-SE	NW-SE	NW-SE	

(b) Ambient water quality

Ambient water quality was measured at the sampling points (H1 and H2 in Figure 5-2-13). The measured items are temperature (surface, upper and lower layers), pH, EC, TDS, TSS, Total Hardness, DO, BOD5, COD, TOC, Ca, Mg, Na, K, Cl, NO_3, SO_4, Cl_2, NH_4 (as ammonia), P, Al, Fe, Cd, Cr, Cu, Mn, Ni, Pb, Zn, B, Si, As, Hg and Oil & Grease.

One liter of surface water sample was collected from each of sample location with a clean water container. Some items such as water temperature, pH, were measured during water sampling at the sample locations, using portable devices. These field work devices have been calibrated before and after the measurements.

Other items were analyzed at IWW[15] in Mülheim, Germany, according to ISO standard methods.

The result of the survey is summarized in Table 5-2-12.

[15] Rheinisch-Westfälisches Institut für Wasserforschung geminnützige GmbH (IWW Water Reserch Institute), Germany

Table 5-2-12 Ambient water quality

Parameter	Unit	Location		Testing method	Iraqi Standard
		H1	H2		
Temperature	°C			Electrometric	-
Surface		28.7	28.8		
10 cm depth		28.9	28.8		
20 cm depth		28.9	28.9		
pH		8.05	8.14	Electrometric	6.5-8.5
EC	microsiem./cm	4474	4533	DIN EN 27888	-
TDS	mg/l	2860	2900	Calc. accord. to EC	-
TSS	mg/l	55	60	Standard method	-
Total Hardness	mg/l	1111.0	1103	Calc. accord to Ca and Mg ions.	-
DO	mg/l	9.1	9.4	Electrometric	< 5.0
BOD_5	mg/l	3.8	3.3	Azide Modific. at 20 °C, 5 days.	> 5.0
COD	mg/l	42	31	Standard method	-
TOC	mg/L	3.1	3.3	DIN EN 1484	-
Ca	mg/l	199	198	DIN EN ISO 10304-1	-
Mg	mg/l	147	146	DIN EN ISO 10304-1	-
Na	mg/l	577	576	DIN EN ISO 10304-1	-
K	mg/l	10.9	11.9	DIN EN ISO 10304-1	-
Cl	mg/l	769	784	DIN EN ISO 10304-1	200
NO_3	mg/l	< 5.0	< 5.0	DIN EN ISO 10304-1	15
SO_4	mg/l	963	981	DIN EN ISO 10304-1	200
Free Cl_2	mg/l	0.1	0.02	EPA 334.0	-
NH_4	mg/l	3.0	3.5	EPA 350.3	-
P	mg/l	< 0.10	< 0.10	DIN EN ISO 10304-1	0.4
Al	mg/l	< 0.10	< 0.10	DIN EN ISO 11885	0.1
Fe	mg/l	0.41	0.58	DIN EN ISO 11885	0.3
Cd	mg/l	< 0.002	< 0.002	DIN EN ISO 11885	0.05
Cr	mg/l	< 0.010	< 0.010	DIN EN ISO 11885	0.05
Cu	mg/l	0.012	0.005	DIN EN ISO 11885	0.05
Mn	mg/l	< 0.010	< 0.010	DIN EN ISO 11885	0.1
Ni	mg/l	< 0.020	< 0.020	DIN EN ISO 11885	0.1
Pb	mg/l	< 0.02	< 0.02	DIN EN ISO 11885	0.05
Zn	mg/l	< 0.10	< 0.10	DIN EN ISO 11885	0.5
B	mg/l	0.68	0.68	DIN EN ISO 11885	1.0
Si	mg/l	5.39	5.34	DIN EN ISO 11885	-
AS	mg/l	0.0024	0.0025	DIN EN ISO 11969	0.05
Hg	mg/l	< 0.00010	< 0.00010	DIN EN 1483	0.001
Oil & grease	mg/l	17.9	14.0	EPA 418.1	-

Regarding the salinity, the figures of TDS show high value (2860 mg/l at H1 and 2900 mg/l at H2), which indicates the river water around the Nasiryah Power Plant is brackish (i.e. the salinity is high).

(c) Noise

Noise survey was carried out at the sampling points (E1 and E2 in Figure 5-2-13) for 24 hours. The measurements were conducted using a sound level meter (Noise meter) type Lutron, SL-4012. The sound level meter was oriented towards the dominant noise source (i.e. Nasiryah TPP) during the measurements at a height of 1.5 meter above ground level.

The result of the survey is summarized in Table 5-2-13.

Table 5-2-13 Noise level at E1 and E2

Location				Standard (dB): Industrial and commercial area
E1		E2		
Time	Noise (dB)	Time	Noise (dB)	
10:00 AM	68.0	11:00 AM	59.0	70
12:00 PM	63.5	1:00 PM	47.0	70
2:00 PM	65.0	3:00 PM	50.0	70
4:00 PM	68.0	5:00 PM	47.0	70
6:00 PM	67.0	7:00 PM	53.0	70
8:00 PM	64.0	9:00 PM	48.0	70
10:00 PM	62.0	11:00 PM	46.0	70
12:00 AM	64.0	1:00 AM	45.0	70
2:00 AM	65.0	3:00 AM	45.0	70
4:00 AM	66.0	5:00 AM	45.0	70
6:00 AM	69.0	7:00 AM	50.0	70
8:00 AM	70.0	9:00 AM	49.0	70

The weather condition around the site is summarized in Table 5-2-14. The wind speed is low, which indicates that the weather condition did not affect the measurement of the noise.

Table 5-2-14 Weather condition at the noise sampling site (E1)

Time	Temperature (°C)	Relative humidity (%)	Wind speed (m/s)
10:00 AM	46.6	17.2	0.3
12:00 PM	47	15.5	0.3
2:00 PM	46	18	0.2
4:00 PM	44	21	0.2
6:00 PM	41	22	0.2
8:00 PM	33	24	0.2
10:00 PM	31	27	0.3
12:00 AM	28	28	0.4
2:00 AM	22	30	0.3
4:00 AM	27	31	0.3
6:00 AM	32.5	24	0.3
8:00 AM	33	26	0.3

(d) Vibration

Vibration survey was carried out at the sampling points (E1 and E2 in Figure 5-2-13) for 24 hours. The measurements were conducted using a vibration meter type Lutron, VB-8200. The vibration values are expressed as velocity vibration (peak particle velocity: PPV in the unit of mm/s). The measurement took place as the sensor was put on flat surface on the ground at the points.

The result of the survey is summarized in Table 5-2-15.

Table 5-2-15 Vibration level at E1 and E2

Location				Standard (PPV) mm/s
E1		E2		
Time	Vibration (PPV) mm/s	Time	Vibration (PPV) mm/s	
10:00 AM	0.2	11:00 AM	1.0	15
12:00 PM	1.2	1:00 PM	0.9	15
2:00 PM	0.5	3:00 PM	0.8	15
4:00 PM	0.3	5:00 PM	0.6	15
6:00 PM	1.1	7:00 PM	0.3	15
8:00 PM	0.7	9:00 PM	0.6	15
10:00 PM	0.6	11:00 PM	0.7	15
12:00 AM	0.5	1:00 AM	0.7	15
2:00 AM	0.6	3:00 AM	0.6	15
4:00 AM	0.7	5:00 AM	0.4	15
6:00 AM	1.0	7:00 AM	0.6	15
8:00 AM	0.8	9:00 AM	0.7	15

The vibration levels at the points do not exceed the limitation for an industrial / commercial building under the British standard.

5.3 Basic Design

5.3.1 Design Standard and Pre-conditions

(1) Agreements

The Study Team and the Iraqi team agreed the following design standard and pre-conditions for Power Plant Design;

1. Once through river water cooling is not permitted, since shortage of river water is expected in future.
2. New power plant must be connected to 400kV network. 400kV Switchyard shall be 1-1/2 circuit breaker configuration. 400kV shall be linked to 132kV via auto-transformer.
3. System parameters shall be studied by MOE using PSSE software considering LFC, AGC and economic dispatch for Iraqi network.
4. Control system for new power plant shall include SCADA system to communicate with dispatch control centre.
5. Diesel oil shall be used for back-up fuel for gas turbine. Back up storage capacity of diesel oil is 15 days for continuous rated power operation of the plant.
6. Emergency diesel engine generator shall be provided for safe shut down. Black start capability is not required.
7. Gas regulation system (GRS) shall be included in the Project. MOE expects to apply new natural gas pipe line to be provided by Ministry of Oil (MOO).
8. English shall be applied for all the documentation, labels in plants and distributed control system (DCS) operator graphic display.

(2) Ambient Temperature

Based upon the temperature records recently observed and publically available for the city of Nasiryah, the following temperature conditions are tentatively applied for the basic design in this study.

	Dry Bulb	Wet Bulb
Design	30°C	15°C
Summer High	50°C	25°C
Winter Low	5°C	5°C

(3) Fuel

The following characteristics of natural gas are tentatively assumed in the design of this study.

- LHV (Low Heating Value)	46,414 kJ/kg
- Methane (C1H4)	90.0 mol %
- Ethane (C2H6)	5.0 mol %
- Propane (C3H8)	2.0 mol %
- Nitrogen (N2)	1.0 mol %
- Carbon Dioxide (CO2)	2.0 mol %

Iraq team provided the specification of gas from the pipeline for a reference. Because of the timing of the information, the specification provided is not applied in this study. However its characteristics of richer in higher carbon component may influence to gas turbine combustors design and should be evaluated further in the tender development.

(4) Water

The raw water source of Nasiryah II is Euphrates River. However Euphrates River is concerned for recent drastic decreasing of the discharge and increasing of the salinity in the river water. The following nominal conditions are tentatively assumed for this study.

- river discharge approx. 10m3/sec
- river salinity approx. 6,000ppm (up to 9,000ppm in maximum)

In order to cope with this situation for the long time periods through the plant life, Nasiryah II Thermal Power Plant is recommended to be designed with the least water consumption philosophy to minimize the risk of water deficiencies and desalination capabilities to produce amount of fresh water required including the use of Hybrid ACCs.

5.3.2 Optimization of Power Generation Plan and Plot Plan

(1) Basis of Nasiryah II Thermal Power Plant

In Chapter 4, the fuel and the plant type of Nasiryah II are recommended to be natural gas and combined cycle thermal power plant (CCTPP).

Because of the apparent economical advantages for larger generating capacities, Nasiryah II is expected to have 4 (four) advanced 300MW class gas turbines which will produce approximately 1,800MW in combined cycle operation.

(2) Shaft Configuration

Multi-Shafts 2 on 1 configuration is recommended because of advantages of;

- Simple Cycle operation applicable with bypass dampers and stacks over Single-Shaft configuration
- Less cost over Multi-Shafts 1 on 1 configuration

With 4 (four) gas turbines, 2 (two) trains of Multi-Shaft 2 on 1 CCTPP are to be installed to Nasiryah II Thermal Power Plant.

(3) Steam Turbine Condensers Cooling

Steam turbine condensers cooling system is one of key features of the thermal power plant. Because it transfers extremely large amount of waste heat from steam turbine exhausts to the environment, site specific conditions should influence to the selection of the adequate cooling method. The general approach is shown in Figure 5-3-1 how to select the cooling system options assuming river as the cooling water resource.

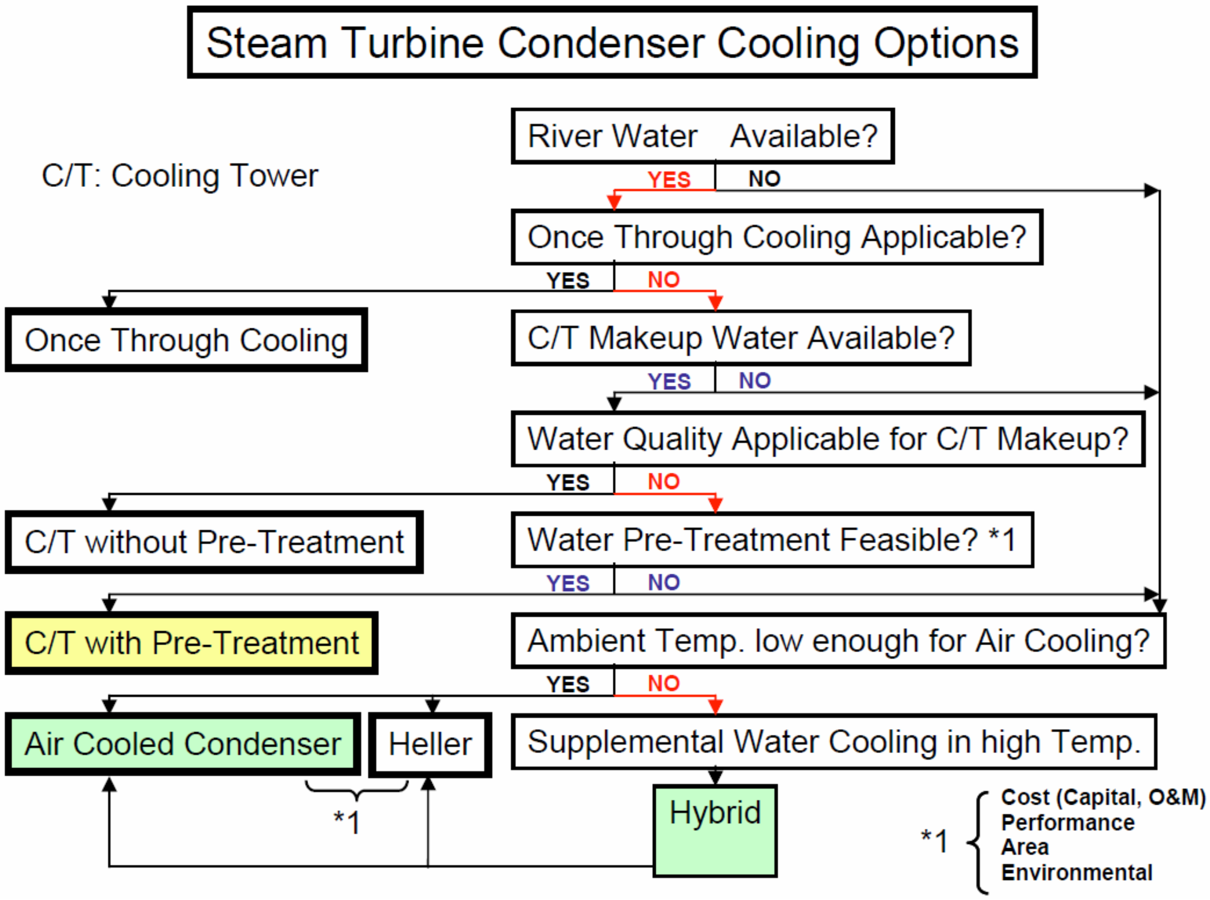


Figure 5-3-1 Steam Turbine Condenser Cooling System Selection Chart

Although Nasiryah II site is located adjacent to the Euphrates River, once through river water cooling is not applicable because of recent decreasing of river water discharges.

Recent degradation of Euphrates River in water quantities and qualities also raises concerns to secure even make up waters to wet cooling towers. As mentioned in 5.2.2.(3)Hydrographic survey.

Air cooled condensers (ACCs) are the common practice of turbine condenser cooling where water resource is very limited. However in extreme high ambient temperature conditions, ACC will cause bad condenser vacuum which may shutdown or damage steam turbines.

To resolve difficulties above, ACC with supplemental water spray cooling (Hybrid ACC) is recommended. Because water spray will only be required in extreme hot conditions, total water consumption of Hybrid ACC will be extremely reduced in comparison with wet cooling towers.

The presentation material attached to the minutes of meeting of the 4th mission of this study in Feb. 2012 held in Istanbul should be referred for more detailed investigation process and information of the steam turbine condenser cooling options.

(4) Desalination Facilities

The qualities of Euphrates River water is found almost to be brackish and not adequate to be applied directly to the power plant raw water supply. Desalination facilities are required to produce fresh water applicable to make up the power plant water use. The desalination capacity will be decided taking into account the supplemental water spray to Hybrid ACCs in extreme hot hours and capacities of buffer storages.

(5) Emergency Fuel

On site diesel oil storage is required as the emergency fuel.
To cope with this requirement, gas turbines are required to have dual fuel firing capabilities of natural gas as main fuel and diesel oil.
15 days of storage capacity requirement may able to be reviewed for potential reduction in future according to the improved reliabilities of main fuel natural gas supply.

(6) Plot Plan

The plot plan is shown in Attachment - 5.
The Nasiryah II site is located south next to the existing Nasiryah Thermal Power Station.
The site is an odd-shaped trapezoid approx. 1.5km long in East-West direction but only 150m to 300m in North-South direction.

Each CCTPP train consists of;

- 1 (one) GTG building which houses 2 (two) gas turbine generators
- 2 (two) bypass dampers and stacks
- 2 (two) heat recovery steam generators
- 2 (two) main exhaust stacks
- 1 STG building which houses 1 (one) steam turbine generator
- 3 (three) generator step up transformers
- 1 (one) set of hybrid air cooled condensers

Air cooled condensers are the major constraining factor to the plot planning because of its extremely large size, the minimum distance requirement to the steam turbine and noise mitigation clearance to the site boundaries.

Other than CCTPP trains, water related system shares large area in the plot plan. Water related systems include desalination, water demineralization, waste water treatment and storage tanks and pumps. River water intake and discharge facilities are also located respectively at the riverbank upstream and the downstream to the existing power station.
Table 5-3-1 shows rough estimation of expected area for facilities in Plot Plan.

Table 5-3-1 Plot Area of Facilities

Ref. No. in Plot	Facility	Area	Notes
1, 2, 3, 4, 8, 25	Power Generation Equipment Area	1.8 ha/train x 2 trains	Within envelope of power block train except ACC
7	Air Cooled Condenser System Area	1.2 ha/train x 2 trains	
5	Diesel Oil Tank Area	1.8 ha	
6	Fuel Gas Treatment Facility Area	0.03 ha	
9	Raw Water Treatment Facility Area	0.3 ha	
10, 13	Dematerialized and Service Water Tank Area	0.7 ha	
11, 12, 14, 17	Water Treatment Facility Area	0.5 ha	
15, 16	Admin. and Workshop Buildings Area	0.5 ha	
20	Control Building Area	0.03 ha	
18, 19	Aux. Boiler and Air Compressor Buildings Area	0.14 ha	
21, 22, 23, 24	Waste Water Treatment Facility Area	0.3 ha	
26	Guard House, Garage, Car Parking	0.13 ha	
	Road, and surplus Area	10 ha	Water intake and discharge facilities not included
	Total	21 ha	BL assumed to be an envelop of plant facilities

(7) Heat Balance

Scarcity of water due to reduced water flow in the Euphrates River and wide ambient air temperature fluctuation at site has the major impact on the heat balance on the proposed combined cycle plant. With overall consideration of site situation hybrid Air Cooled Condenser (hybrid ACC) has been selected as the device for cycle heat rejection from steam turbine condenser. During hot summer days when ambient temperature is near 50°C, spray water is required to cool the inlet air of ACC to keep the vacuum in ACC to acceptable limit. Any other time of the year dry ACC can cater to the required heat absorption to keep the vacuum in the condenser to the required limit. Please refer Heat Balance diagram at 50°C, 30°C and 5°C ambient temperature in Attachment - 6.

(8) Water Balance

Water balance diagram is shown in Attachment - 7.
Two major users of water are as follows.

- Boiler water make up
- ACC supplemental cooling water injection

There are miscellaneous water users mostly common in general CCTPPs also as shown in the diagram.

Euphrates River is the raw water resource to the Nasiryah II. Because of its high salinity, up to 9,000ppm, desalination process should be applied to supply fresh water. RO desalination system, assumed in this study, will produce not only fresh water but also amount of reject water with very high salinity more than 30,000ppm. High salinity reject water will be discharged back to Euphrates River. If high salinity discharge is not acceptable from environmental regulatory view, counter measures will be taken such as dilution or zero liquid discharge (ZLD).

(9) Performance

The CCTPP performance analyzed by GT-Pro/PEACE are summarized in the Table 5-3-2

Table 5-3-2 CCTPP Performance Summary (2 trains of 2 on 1 CCTPP)

		Air Cooled Condenser (Hybrid)		
Amb. Temp	℃	10	30	50
Gross Output	MW	1865.6	1688.5	1435.3
Gas Turbine Generators	MW	1271.0	1131.3	971.8
Steam Turbine Generators	MW	594.6	557.2	463.5
Gross Efficiency	%	58.3	57.8	55.0
Aux. Power	MW	57.6	55.1	54.3
Net Output	MW	1807.8	1633.4	1381.0
Net Efficiency	%	56.5	55.9	52.9
Cooling Water Consumption	t/h	0.0	0.0	590.8
Cooling Fan Power	MW	11.6	11.6	11.6
CWP Power	MW	0.0	0.0	0.0
Desali. Water Production	t/h	400.0	400.0	1200.0
Desalination Power	MW	1.0	1.0	3.1

Auxiliary powers in Table 5-3-2 are a little different from those indicated in heat balance diagrams of Attachment - 6. Heat balance diagrams assume the full capacity operation of desalination plant respectively. However actual water consumption will be less than the full capacity of desalination plant especially for supplemental cooling of ACC depending on ambient temperature. Auxiliary power consumption of desalination plant will also be less than the full capacity operation. Auxiliary powers and net outputs in Table 5-3-2 are corrected accordingly from those in heat balance diagrams.

5.3.3 General Specifications of Major Facilities

(1) Overall Combined Cycle Thermal Power Plant (CCTPP) Configuration

Nasiryah II Thermal Power Plant to be located south next to the existing Nasiryah thermal power station applies the gas fired combined cycle power generating system with 300MW class advanced F-technologies heavy duty gas turbines. The conceptual power plant configuration is presented in Attachment - 5, the Overall Schematic Diagram.

Nasiryah II is planned to have 2 (two) trains of "2 on 1" CCTPP. Each "2 on 1" CCTPP train consists of 2 (two) gas turbine generators (GTGs), 2 (two) heat recovery steam generators (HRSGs) and 1 (one) steam turbine generator (STG). Each "2 on 1" CCTPP train is expected to produce approx. 800MW of net electrical output with 56% net efficiencies nominally in Nasiryah II site conditions. GTGs and STGs are housed in turbine buildings with overhead cranes.

The main fuel of gas turbines is natural gas fed to the site by the pipeline branched from the main national gas pipeline running several kilometers away from the Nasiryah II site. Fuel gas booster compressors may be required to compensate the pressure required at the combustors of gas turbines. Gas turbines will also have dual fuel capabilities to operate on diesel fuel oil as emergency fuel.

Each gas turbine is connected to the dedicated HRSG with exhaust gas ducts and the bypass damper. The bypass damper diverts the exhaust gas flow either to the HRSG for the combined cycle mode or to the bypass stack for the simple cycle mode. Bypass dampers and stacks will allow the earlier commissioning of GTGs with the simple cycle operation than the entire combined cycle commissioning.

HRSGs are sub-critical steam boilers which convert the residual heat of hot gas turbine exhaust gas to the steam of high temperature and high pressure. Nasiryah II applies the triple pressures steam cycle for excellent thermal efficiencies of STGs. Two (2) HRSGs in a CCTPP train will feed steams to the common STG of the same train. Exhausts from HRSGs are discharged to the environment through main stacks, Continuous emission monitoring system (CEMS) is provided to monitor the exhaust at the main stacks.

Steam turbines are condensing type with air cooled condensers (ACCs). ACCs condense the turbine exhaust steam in fin tubes directly with the motor-driven fan induced air flow and need no cooling water. ACCs are considered as the most practical condenser cooling option in consistent with the serious water resource concerns (quantities and qualities) of Euphrates River. However the vacuum in ACCs will not be good enough to operate ordinal condensing turbines in extreme high temperature hours in Nasiryah such as 50°C. Supplemental water sprays are installed to cool the ACC inlet air temperature down enough to achieve the good vacuum in the ACCs in extremely hot hours.

Euphrates River shows very high salinity even 9,000ppm at the maximum. To make Euphrates River the power plant water source, desalination system should be applied. Reverse osmosis (RO) desalination system is applied in this study. Desalination system produces desalinated water of the fresh water grade with the salinity below 1,000ppm. Because of its very muddy and organic rich nature, the raw water from Euphrates should extensively be pre-treated for solid material removal before entering to the RO system to protect the sensitive RO membranes.

Desalinated water is supplied to water users through the service water system. The water demineralization system produces demineralized water for boiler make up and other demineralized water users such as hydrogen generators and combustor injection water for emergency liquid fuel firing to control NOx generation.

Fin fan coolers are applied to cool the closed cooling water for auxiliary cooling. Supplemental water injection may be required to control the cooling water temperature within the specification in extremely hot time.

Electrical power output of generators are supplied to the grid through isolated phase bus ducts (IPBs), generator circuit breakers (GCBs), generator step up transformers (GSUTs), 400kV cables in trenches and gas insulated switchgear (GIS) substations which will be located in the Nasiryah I area. Unit auxiliary transformers (UATs) supplies auxiliary power to the plant auxiliary power distribution system either from the grid in plant startup or from generators in normal operation.

Nasiryah II is monitored and controlled mostly through the distributed control system (DCS). Human machine interface (HMI) systems are located in the main control room. Interfaces are provided between DCS and local items such as instrumentation, actuators and switches. GTGs and STGs are supplied with dedicated control systems which communicate with DCS.

(2) Gas Turbine Generators and Steam Turbine Generators

(a) Gas Turbine and Generator Set

1) Outline of Gas Turbine

300MW-class gas turbine consists of high efficiency axial compressor, a combustion chamber equipped with can type combustors arranged in circular array around the engine, and a 4-stage reaction type turbine. The gas turbine is directly coupled to the generator at the compressor end.

Ambient air is drawn through the inlet manifold and inlet casing into the compressor. It is pressurized and fed into the combustors, where it is mixed with fuel to burn. The high pressure and high temperature combustion gas then expands through the turbine, dropping in pressure and temperature as the thermal energy is utilized and converted into mechanical work. A portion of the power thus developed by the turbine is used for driving the compressor, with the balance of power used to drive the generator. The expanded gases are then exhausted to atmosphere through an exhaust stack via a heat recovery steam generator (HRSG) in a combined cycle plant.

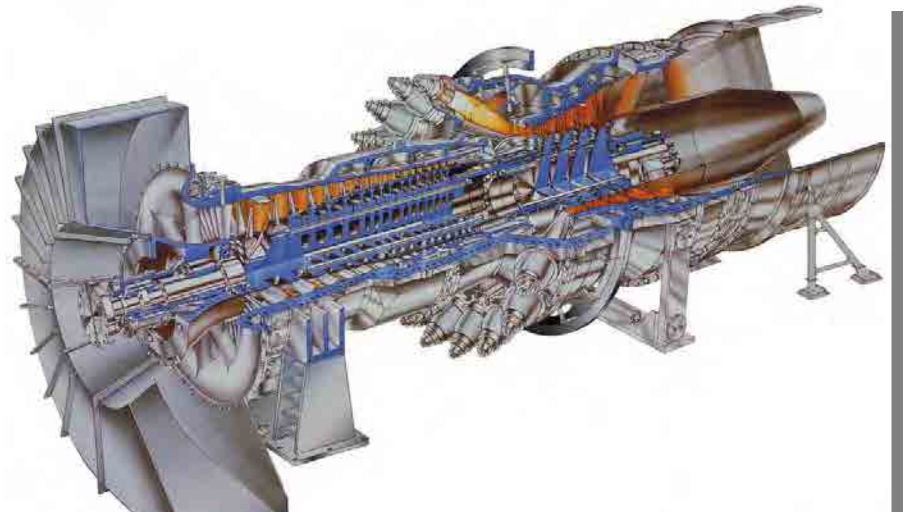


Figure 5-3-2 300MW Class Heavy Duty Gas Turbine

2) Casings

All engine casings are horizontally split to facilitate maintenance with the rotor in place. Inlet and compressor casings are of nodular cast iron and cast steel, respectively. Combustor, turbine, and exhaust casings are mild or alloy steel. The inlet bearing housing is supported by eight radial struts, and the turbine end bearing housing is supported by six tangential struts.

3) Rotor assembly

The single rotor is made up of compressor and turbine components supported by two tilting-pad bearings. The thrust bearing is a double acting multi-pad type thrust bearing that uses leading edge groove lubrication.

The compressor rotor is comprised of a number of elements that are spigotted and bolted together by the through bolts. The turbine rotor section is made up of discs are bolted together by the through bolts and using CURVIC clutches, which consist of toothed connection arms that extend from adjacent discs and interlock providing precise alignment and torque carrying features.

4) Compressor

The air inlet system, which contains a silencer, delivers air to the compressor via a plenum-bell mouth and houses the inlet, main journal, and thrust bearings. The compressor is axial flow design of high pressure ratio that is based on the highly successful experienced compressor.

The compressor is also equipped with variable inlet guide vanes, which improve the compressor low-speed surge characteristics and are used in combined cycle applications for improved part-load performance.

5) Combustion system

The combustion system consists of can-annular combustors with natural gas firing capability.

The dry low NOx (DLN) combustor features a three stages burner assembly and a bypass valve, directs a portion of the compressor delivery air directly into the transition piece to enhance flame stability during starting and to maintain desired fuel/air ratio during loading. This unique valve system then is modulated to full closed at fully load.

6) Turbine

The turbine design maintains moderate aerodynamic loading despite the increased inlet temperature by choosing a four-stage turbine. Furthermore, improvements in aerodynamic airfoil shapes have been made possible by utilization of a fully three dimensional computer flow analysis. This sophisticated airfoil design approach was employed to ensure that the turbine has the highest practical aerodynamic efficiency.

7) Starting System

The static frequency converter starting system is the driver that utilizes the generator as the motor to bring the unit to self-sustaining speed during the starting cycle.

When reaching the self-sustaining speed of the gas turbine, the starting system is consecutively de-energized, and the gas turbine reaches its rated speed by itself.

8) Turning System

The turning system provides to rotate the shaft of the gas turbine at the low speed to cool down the unit after shutdown, and to assist the starting device in overcoming the initial break-away torque. The turning gear, connected to the generator shaft end at exciter side, is of automatically engaged and disengaged type driven by an AC motor.

9) Lubricating Oil System

The lubrication system supplies clean, filtered oil at required temperature and pressure for lube requirements of the gas turbine, generator / exciter and auxiliaries. In addition, the oil is used to pressurize the overspeed trip system. Most lube system operational components are located on the lube oil supply unit of which the lube oil reservoir is an integral part.

Oil is pumped into the system by an AC-power main lube pump that is backed by another main lube oil pump. Further, if the outlet pressure of operating and standby main lube oil pumps drops below the set point a DC-power emergency lube oil pump will switch on to deliver oil from the reservoir directly to shaft bearings and to the hydrogen seal oil system.

10) Control Oil System

The gas turbine incorporates hydraulic operated valves for more accurate and faster control of critical valves such as fuel pressure control valves, fuel flow control valves, fuel shut-off valves and so on.

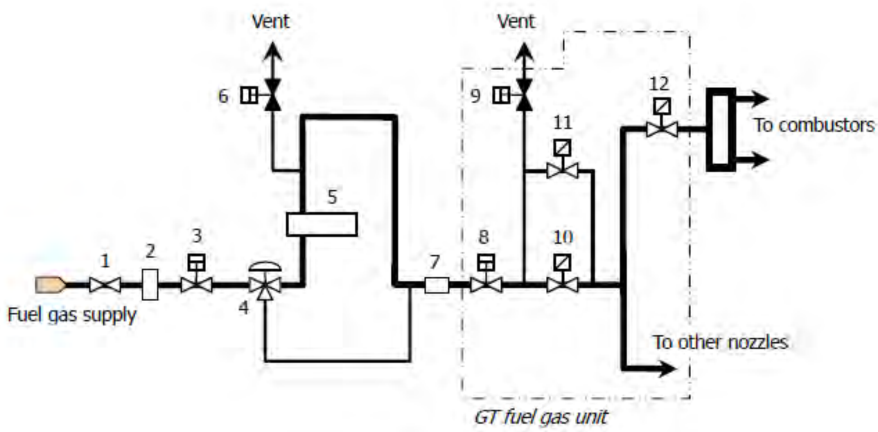
A separate control oil supply unit is provided for supply of necessary high pressure control oil at designated pressure and cleanliness to the valve actuators. A skid mounted reservoir and dual pump unit together with filters and a cooler are incorporated on a closed loop.

11) Unit Fuel Gas System

The system includes all equipment, valves, piping and instrumentation required to control the flow of fuel gas into the combustors.

Most components of the fuel gas system are located in the GT fuel gas unit adjacent to the GT enclosure. Components not included in the fuel gas unit, such as the flow meter, emergency shut-off valve, temperature control valve, fuel gas heater, emergency vent valve and inlet strainer are provided individually.

The fuel gas heaters recover the energy of the steam from the HRSG to increase the fuel gas supply temperature and contribute to improve the plant thermal efficiency.



Key

1	Unit isolation valve	7	Strainer, fuel gas inlet
2	Fuel gas flow meter	8	Fuel gas shut-off valve
3	Fuel gas emergency shut-off valve	9	Fuel gas vent valve
4	Fuel gas temperature control valve	10	Fuel gas supply pressure control valve (A)
5	Fuel gas heater	11	Fuel gas supply pressure control valve (B)
6	Fuel gas emergency vent valve	12	Fuel gas flow control valve

Figure 5-3-3 Unit fuel gas system outline

12) Turbine Cooling Air System

Cooling circuits for the turbine section consist of a rotor cooling circuit and four stationary cooling circuits. Rotor cooling air is provided by compressor discharge air extracted from the combustor shell. This air is externally cooled and filtered before returning to the torque tube casing for seal air supply and for cooling of the turbine discs as well as the first, second and third-stage turbine rotor blades.

13) Inlet Air System

The standard inlet air filtration system includes two stages of unit filters. The first component consists of hoods, louvers to stop leaves, birds and trash. This is followed by a pad-type pre-filter and a final filter. Other inlet filter configurations including a pulse, self-cleaning filter are available. Sand storm condition in the area of Nasiryah should be taken into account to the design of inlet air filtration system.

A top-inlet air duct directs flow into the compressor inlet manifold. The manifold is designed to provide an efficient flow pattern of inlet air into axial-flow compressor. A parallel-baffle silencing configuration is located in the inlet system for sound attenuation.

Inlet air cooling system, such as evaporative cooling or fogging, may be applicable to compensate the reduction of output in high ambient temperature conditions. Applicability of inlet air cooling system will need to be investigated not only for output compensation but also for water consumption.

14) Exhaust Gas System

After expanding the gas turbine, the turbine exhaust gas is discharged to atmosphere through the by-pass stack during simple cycle operation.

At combined cycle operation, the gas pass of by-pass stack side is closed and the exhaust gas is flowed down to HRSG.

The system containing;

a) Expansion joint between turbine exhaust and exhaust duct
b) Single diverting type damper for the by-pass stack side and the heat recovery boiler side. Blades inter-space for sealing is pressurized by seal air.
c) Exhaust gas duct with connection flanges for the by-pass stack and HRSG.
d) The by-pass stack including the silencer

15) Package Fire Fighting System

The fire fighting system applied for gas turbine protection is an automatic total flooding type, high pressure carbon dioxide fire protection system. The system is designed to detect fire automatically with extinguishing discharge automatically or via manual release push button at every entrance door of protected GT enclosure/Fuel gas unit enclosure. In the event of a fire, the carbon dioxide will discharge evenly through the fixed pipings and via the nozzles into the protected enclosure.

16) Gas Turbine Generator

Gas turbine generator will be designed and manufactured based on the following basic conditions;

a) Stator winding and core are hydrogen cooled type and rotor winding is also hydrogen cooled type.
b) Stator winding and core are hydrogen cooled type and rotor winding is also hydrogen cooled type.
c) Generator excitation system is static type.
d) Hydrogen sealing is vacuum-treating-type seal oil system.

17) Specification of Gas Turbine Generator

Type	Horizontally mounted cylindrical rotor, rotating field type with explosion proof structure
Number of poles	2
Rated speed	3,000 min-1
Number of phases	3

Cooling system	
Stator coil	Hydrogen indirectly cooled
Rotor coil	Hydrogen directly cooled
Excitation system	Static
Insulation class and temperature rise	
Stator coil	Class F, IEC-B rise
Rotor coil	Class F, IEC-B rise

(b) Steam Turbine and Generator Set

1) Outline of Steam Turbine

This unit consists of two cylinders, double down exhaust, condensing reheat turbine designed for high operating efficiency and maximum reliability.

The HP steam from one set of the HP stop valve and HP control valve enters the HP turbine through an inlet pipe.

The steam flows through the HP blading producing the power, decreasing its pressure and temperature, and enters the HRSG.

The IP steam from HRSG enters the IP turbine through an inlet pipe and enters the IP blading.

The LP steam from the LP stop and LP control valves is mixed with the IP turbine exhaust flow at cross-over piping between HP-IP turbine and LP turbine.

The steam flows through the LP blading and flows through as exhaust cone, thence to a condenser.

The low pressure element incorporating high efficiency blading, and diffuser type exhaust, and improved exhaust hood design have resulted in a significant improvement in turbine heat consumption.

2) Steam Turbine Component

a) Combined HP-IP Turbine

The HP turbine and IP turbine are combined into one cylinder, thus forming a compact overall steam turbine. The combined HP-IP turbine is designed to eliminate excessive thermal stress and thermal distortion during start up and load changes.

The internal parts of the turbine are separated from each other and supported in a thermally flexible manner in order to reduce thermal distortion and thermal stress.

i) HP-IP Blading

The HP-IP stages consist of high-performance blades. These blades are designed using the latest flow analysis around the blade. And the blades are of ISB, or integral shroud blade, i.e., shrouds and blade profile are manufactured from one piece, not separately manufactured and assembled.

ii) HP-IP Rotor

The HP-IP turbine rotor is machined from solid alloy steel forging with excellent creep rupture strength characteristics. The rotor diameters are so selected to provide adequate separation of their critical speeds from the running speed.

The smooth surface geometry is carefully designed to reduce stress concentration for both the transient thermal stress and the bending stress.

The coupling is solid type to prevent the rotor misalignment.

iii) Casing, Dummy Ring, Diaphragm

The structural shape of the casings and their support method are carefully designed to obtain free but symmetrical movements due to temperature changes and thereby reduce the possibility of distortion to minimum.

b) LP Turbine

LP turbine has symmetrical double flow construction.

The outer cylinder and inner cylinder distribute the temperature differential between the inlet and the condenser so as not to impose thermal stress and prevent distortion of the cylinder.

The use of diffuser type exhaust flow guides and a large exhaust hood configuration minimize exhaust loss.

i) LP Blading

Bladings upstream in the LP turbine are used as the high-performance reaction blades. Careful consideration is given in the low pressure end blade design for prevention of erosion as well as improved performance.

The moisture, or drip flow, in the blade paths has been investigated and the results have been incorporated into the design of the blade path.

ii) LP Rotor

The low pressure rotor is machined from solid alloy steel forging of high tensile strength with excellent ductility qualities.

The low pressure rotor is connected to the generator by a rigid coupling.

iii) LP Casing

The LP casing consists of a steel plate structure, which prevents cylinder distortion due to the temperature differential between the inlet and exhaust.

The low pressure casing, with a double flow arrangement, has a fabricated cover and fabricated base and is split in the horizontal plane.

3) Turbine Valves

a) HP Stop Valve

The turbine has one HP stop valve which is driven by hydraulic servomechanism.

This is an oil operated "Plug" type valve operating in a horizontal position with the body formed as an integral part of the steam chest.

The steam strainer cylindrical in shape fits around the valve.

b) HP Control Valve

The turbine has one HP control valve which is controlled by individual hydraulic servomotor.

The steam valve is a ring sealed plug type valve mounted on the shouldered valve stem. The diameters of upper seat and lower seat of the valve are so designed as to balance the steam pressure force acting on the valve. Thus the valve can be open and closed easily at any pressure.

c) IP Stop Valve

The turbine has one IP stop valve which is driven by on-off control of a servomotor.

The IP stop valve is a swing check type valve.

d) IP Control Valve

The turbine has one IP control valve which is controlled by individual hydraulic servomotor.

The steam valve is a ring sealed plug type valve mounted on the shouldered valve stem. The diameter of upper and lower valve seats are so designed as to balance the steam pressure force acting on the valve. Thus the valve can be opened and closed easily at any pressure.

e) LP Stop Valve and Control Valve

The turbine will be provided one LP stop valve and one LP control valve which are driven by hydraulic servomotors.

The LP stop valve and LP control valve are of butterfly type.

f) On Load Testing of Valves

Testing equipments for smooth movement of the valve while unit is in operation is provided.

HP, IP, and LP inlet are provided with only one line respectively. Therefore, only one stop valve is provided for each line, and partial stroke test will be conducted.

4) Lubricating Oil and Associated Trip System

a) Control and Lubricating Oil System

The lubricating oil is commonly used as the control oil for main valves. Control oil is tapped from the lube oil system. In order to simplify the description, the oil system can be divided into three parts, namely:

i) High pressure oil system
ii) Lubrication oil system
iii) Control oil system

i) High pressure oil system

- The oil discharged by the main oil pump during normal operation is used to provide an oil supply for trip system.
- Filtered high pressure oil is used to operate servomotors of the main valves.

ii) Lubricating oil system

The oil supply for the bearing lubrication system is taken from the main oil pump (LP) discharge, circulated through the oil cooler and routed to the main bearings, thrust bearing and turning gear.

The mail oil pump (LP) discharge pressure is sufficient to assure a positive supply of lubricating oil to the bearings.

A relief valve is provided in the bearing oil line to compensate for moderate changes in oil requirements.

iii) Control oil system

All controls are operated hydraulically utilizing the lubricating oil supplied by the main oil pump.

The oil discharge pressure is used to obtain the required force to actuate servomotor pistons.

b) Protective Devices

Protective devices include the followings:

i) Solenoid trip
ii) Overspeed trip
iii) Low bearing oil pressure trip
iv) Low vacuum trip
v) Thrust trip
vi) Low pressure turbine exhaust spray system
vii) Relief diaphragm to protect low pressure turbine exhaust casing

5) Gland Steam and Drain System

The function of the rotor steam gland sealing system is to prevent leakage of air into, or the steam from, the turbine cylinders along the rotor ends.

This function is accomplished by the following components:

a) Gland Steam Controller

The purpose of the gland steam controller is to supply sealing steam at a constant pressure to the turbine glands throughout the start-up, operation, and shut-down of the turbine.

The controller is adjusted such that at start-up all of the gland sealing steam is supplied from the external steam supply line through the control valve.

As load increases, increment of leakage steam from high pressure gland reduces the required external sealing steam.

b) Gland Steam Condenser

The steam and air mixture leaving the outer gland of the turbine is introduced into a surface type gland steam condenser. The gland steam condenser has two exhaust fans, one of which is for stand-by.

c) Rotor Gland

The rotor glands are of the spring backed labyrinth type. Outer glands are removable without raising the turbine casing cover.

d) Drain System

The most important thing in turbine operation is to never introduce water into the turbine.

Condensation, which may be produced in the turbine at start-up or low load, is routed to the condenser or other equipment through continuous drain orifices and air operated drain valves which shall be open when operating below 20% load.

e) Exhaust Hood Spray

Automatic sprays are provided to prevent high exhaust temperature of LP turbine.

When exhaust hood spray valve is opened, water from the condensate pump discharge to spray nozzles installed in the turbine exhaust hood chambers.

Overheating of the exhaust end is not expected even with no load steam and full vacuum.

The exhaust hood spray is set to control exhaust hood temperature to 70 °C maximum.

f) HP Turbine Casing Cooling Cell

The cooling cell which is fabricated by steel plate is mounted on the upper casing of HP-IP turbine. The purpose of the cooling cell is to prevent the uneven cooling between the upper casing and the lower casing after the steam turbine shutdown.

After the steam turbine shutdown, the casings cool down naturally, however, the lower casing cools down faster than the upper casing. The temperature difference between the upper and lower casings causes the deformation of the turbine casing, which may lead to rubbing between the stationary parts and the rotating parts. The cooling cell cools the upper casing by using service or instrument air, and prevents high temperature difference between the upper casing and the lower casing.

After the steam turbine shutdown, cooling air is supplied to the cooling cell by opening the solenoid valve. When the upper casing temperature becomes lesser than the lower casing temperature, air supply will be stopped, by closing the solenoid valve. The cooling air will not be supplied during the turbine operation.

6) Turbine Turning Gear

The turning gear will be of the automatic engagement type and capable of starting the turbine generator from standstill and driving it continuously at recommended speed, with normal bearing oil pressure.

Suitable pressure interlocking protective devices will be provided to prevent the starting of the turbine generator by the turning gear until the proper oil pressure has been established in the turbine generator bearings.

7) Steam Turbine Generator

Steam turbine generator will be designed and manufactured based on the following basic conditions;

a) Stator winding and core are hydrogen cooled type and rotor winding is also hydrogen cooled type.
b) Generator excitation system is static type.
c) Hydrogen sealing is vacuum-treating-type seal oil system.

8) Specification of Steam Turbine Generator

Type	Horizontally mounted cylindrical rotor, rotating field type with explosion proof structure
Number of poles	2
Rated speed	3,000 min-1
Number of phases	3
Cooling system	
Stator coil	Hydrogen indirectly cooled
Rotor coil	Hydrogen directly cooled
Excitation system	Static
Insulation class and temperature rise	
Stator coil	Class F, IEC-B rise
Rotor coil	Class F, IEC-B rise

(3) Heat Recovery Steam Generator (HRSG) and Hybrid Air Cooled Condenser

(a) Heat Recovery Steam Generator

The HRSGs convert exhaust energy generated by the gas turbines into high-, intermediate-, and low-pressure steam for driving the power station steam turbine. The HRSGs are three-pressure, reheat, natural circulation, drum type with horizontal gas flow.

Proposed HRSG is of cold casing design with horizontal gaspath through vertically arranged heating surface. HRSG consists of the following sections.

- HP Superheater
- Reheater
- HP Evaporator
- HP Economizer
- IP Superheater
- IP Evaporator
- IP Economizer
- LP Superheater
- LP Evaporator
- LP Economizer (Condensate Preheater)

1) Heating Surface

The heating surface consists of number of parallel tubes welded between a bottom and top header, this assembly is sometimes referred to as a "harp". A number of harps together will form a "module". The heating surfaces are top supported. This enables easy downward elongation of the tubes and avoids high thermal stresses. The tubes may be either with or without fins. The fin thickness, density and type of finning (solid or serrated) depend amongst others on the fuels burned in the gas turbine.

The gaspath is formed in between the upper and lower headers over the entire finned length of the tubes. The bare ends of the tubes towards the header will be shielded from direct contact with the exhaust gas to avoid bypass flows.

2) Steam Drum

The boiler is provided with one drum per pressure level. Its main functions are as follows.

- Separation of saturated steam from the water-steam mixture leaving the evaporator
- Acceptance of the swell water from evaporator during start-up
- Concentrate all the dissolved salts in the water/steam circuit
- Maintenance of specified water quality
- Provide limited water storage for control purposes (hold-up)

In order to achieve the foregoing tasks and to ensure the specified steam purity, the drum incorporates the following internals:

a) Steam Separation System
b) Feedwater Distribution
c) Blowdown
d) Chemical Dosing

a) Steam Separation System

This system consists of a primary and secondary separator. The primary separator is a water box with cyclones or baffles installed under the water level in which the steam and water received from the evaporator is separated. The secondary separator is installed in the steam space in the upper part of the drum to limit water carry-over in steam supply to the superheater.

b) Feedwater Distribution

Feedwater is fed to the drum by means of an inner distribution pipe extending over the length of the drum below water level. This ensures a good mixing of feedwater with saturated water in the drum. The feedwater nozzle has a thermal sleeve to avoid thermal stresses in the nozzle.

c) Blowdown

The drum has two blowdown systems, the continuous (or surface) blowdown to reduce the drum water salt concentration and the discontinuous (or bottom) blowdown to remove sludge and scale forming elements before these can settle to the bottom of the drum. The frequency of this intermittent blow down and the amount of water to be flushed depends highly on the nature of the feedwater and the load of the boiler. A second possibility is the eventual removal of excess of water during start-up.

d) Chemical Dosing

In order to maintain the specified water quality and pH, chemicals are added to the water/steam cycle. A nozzle is provided on the drum to inject chemicals from the chemical dosing system.

The drums are mounted on saddles which are supported by the steel structure.

3) HRSG Casing & Steel Structure

The HRSG casing is made from plain carbon steel and is connected to the steel structure to form a structural box to withstand the exhaust gas pressure and to maintain structural integrity.

Platforms along the HRSG are integrated with the support structure and provide suitable access to the drums, instrumentation, valves and inspection doors. The drum platform is accessible by means of a stairway while a cage ladder will serve as escape route. The platforms are provided with hot dip galvanized floor grills and railing.

4) HRSG Stack

The 60m tall HRSG stack made from carbon steel is proposed and is of the single shell type. Continuous Emission Monitoring System (CEMS) to be provided for monitoring of the emission quality.

5) Stack Damper and Silencer

Stack dumper is to be provided. And, no stack silencer is provided, because noise requirement is kept at the ground level.

6) HRSG Insulation

The HRSG is internally insulated up to and including the last heating surface. The internal insulation is build up from one or more layers mineral wool fixed by means of pins to the casing wall and shielded from the exhaust gas by means of an internal liner.

7) Valve

All valves are conform ASME/ASTM, API or BS codes.

(d) Hybrid Air Cooled Condenser (Hybrid ACC)

Cycle heat rejection is accomplished by the hybrid air-cooled condenser. Hybrid ACC has the capability to reduce the cooling air temperature by supplemental water evaporation at the air inlet. As a result during hot summer day when the conventional ACC cannot extract enough heat to create required vacuum in the condenser, hybrid ACC is capable of reducing cooling air temperature by use of water evaporation and can create required vacuum.

The Hybrid ACC is designed to accept full steam production from the HRSG during steam turbine bypass operation without exceeding steam turbine exhaust pressure or temperature limitations.

The typical major components of the heat rejection system are as follows:

- Air-cooled condenser motor driven fan
- Water spray nozzle grid
- Hogging ejector with silencer
- Air extraction system
- Vacuum deaerator
- Exhaust duct from the turbine with expansion joint
- Turbine bypass connections
- Condensate pumps

(4) Balance of Plant

(a) Main Steam System

The main steam system will transport high-pressure (HP), intermediate-pressure (IP), and low-pressure (LP) steam from each HRSG to the steam turbine. The HP section of the main steam system will deliver steam from the HP superheater to the main HP turbine stop valves. Exhaust steam from the HP turbine and from the IP section of the HRSG will then go through the reheater section of the HRSG. Steam from the reheaters will be conveyed to the IP turbine. Finally, the LP section of the main steam system will deliver steam from the LP superheaters to the LP section of the steam turbine together with exhaust from IP turbine.

The main steam system will also include:

- HP steam turbine bypass to cold reheat steam (one for each HRSG) with steam-conditioning equipment
- Hot reheat steam turbine bypass to the condenser (one for each HRSG) with steam-conditioning equipment
- LP steam turbine bypasses to the condenser (one bypass for each HRSG) with steam-conditioning equipment
- Drain connections and accessories for condensate collection
- Valves, instrumentation, and controls for a complete and operable system

The steam turbine bypass systems will be designed to accommodate the steam generated in the HRSGs during startup of the combustion turbines before steam turbine admission, and the steam generated following a steam turbine trip. The bypass system will be sized to allow continuous full-load operation of the combustion turbines with the steam turbine shut down.

The main and reheat steam system will be designed to prevent steam turbine water damage in accordance with ASME TDP-1, Recommended Practices for the Prevention of Water damage to Steam Turbine Used for Electric Power Generation, Fossil Fueled Power Stations. The main steam system drains will be routed to either to the HRSG blowdown tank or the turbine drain recovery tank. The supplier of the steam turbine generator will provide strainers in the steam admission lines to protect the turbine stop and control valves.

(b) Fuel Gas System

Fuel gas system will introduce required fuel gas from the fuel gas delivery pipeline outside of the plant boundary and distribute the fuel gas to the GTGs.

Typical major components of the fuel gas system are as follows;

- Emergency shutdown (ESD) valve
- primary scrubber
- Ultrasonic flow meter with a redundant flow computer
- Fuel gas compressors
- Fuel gas coalescing duplex filters
- Pressure regulating stations
- Electric dew point heater
- Fuel gas performance heater
- Fuel gas scrubber & duplex filter/separator

Fuel gas compressors may be required to compensate gas pressure in consistent with the requirement at the gas turbine combustors.

(c) Closed Cooling Water System

The closed cooling water system supplies cooling water to various plant equipments, such as generator coolers, lube oil coolers, boiler feedwater pumps, fuel gas compressors etc as closed cycle system in order to release heat rejected from each equipment to atmosphere via fin fan coolers.

A fin fan cooler will have multi-bay configuration so that a failure of single fan motor will not initiate shutdown of the equipment of each service.

Typical major components of the closed cooling water system are as follows;

- Fin fan cooler with multi-bay configuration
- Closed cooling water pumps GTG
- Closed cooling water pumps for STG
- Closed cooling water pumps for BOP equipment
- Closed cooling water head tank

(d) River Water Intake and Discharge

River water intake system is described in civil section 5.3.3(7)(f).
River water discharge facility is located at the river bank of Euphrates River.

(e) Water Treatment System

1) Pretreatment & Desalination System

A reverse osmosis (RO) based desalination system will be used for the production of desalinated water from high salinity raw water after from the Euphrates River.
The desalination system will include a pretreatment section including two stages of dual media filtration with coagulant and/or polymer addition for the removal of suspended solids and sediment from the sea water. Filtered water is stored in Filtered water pit.

The RO portion of the desalination system will include complete system with membranes; RO feed pumps, energy recovery devices and chemical dosing systems as required. Treated water from desalinated system is stored in the desalinated water pit.

2) Demineralization System

Desalinated water will be treated by the demineralization water system for supplying make-up water to the steam/water cycle. Demineralization water system will finally be designed based on the raw water characteristics of the river water. However proposed demineralization system will consist of Ultra-filtration (UF) system, Two-pass Reverse Osmosis (RO) system and Electrodeionizer (EDI) system. Raw water will be introduced to the UF system upstream of the RO system for removal of suspended solids. Permeate from UF system is discharged into a buffer tank in order to maintain availability of water to next unit process, during UF automatic cleaning (Backwash or Backpulse). Permeate from UF system is conditioned using sodium bisulfate in order to control the residual chlorine, also anti-sealant is added to prevent salts scaling. The use of sulfuric acid depends of the pH.

RO system has two passes of RO membranes. The water is introduced to the first pass RO membranes and it's permeate will be stored in a RO 1st Pass Permeate Tank. Permeate will be used for domestic non-potable water needs.

The permeate is introduced to the second pass RO membranes by means of booster pumps. Second pass RO permeate will be once discharged into the EDI Feed Tank and sent to EDI system to produce demineralized water by means of EDI Feed Pumps. The demineralized water from the EDI system shall meet the quality requirements specified in the Table-5-3-3.

Demineralized water will be stored in a demineralized water tank.

Reject from the first pass RO membranes will be delivered to the waste water treatment system. Reject from the second pass will be delivered to inlet of the first pass RO menbranes for its recovery. All required reject, bypass, recirculation, and flushing lines will be provided with sufficient automation for unattended operation.

Table 5-3-3 Demineralized Water Specifications

Parameter	Value
Total Dissolved Solids (TDS); ppm	<0.1
Silica as SiO_2; ppb	<10
Conductivity; micromho/cm	<0.1 at 25 C
pH	6.5 to 7.5

(f) Waste Water System

Waste water treatment system is proposed for the treatment of all the liquid waste of the plant and the treated water shall be discharged to the river. However at a later stage if specific environmental regulation require "Zero Liquid Discharge (ZLD)" concept to be adapted in the plant, same can be established.

The following waste water will be generated from the power station and will be treated by waste water system;

- Oil-contaminated water
- Waste water from demineralized water system
- HRSG blowdown
- Chemical waste water
- Storm water
- Sanitary waste water

Oil-contaminated water will be collected in sump pits in each area and delivered to oil separator for removal of oil. Treated water will be delivered to neutralization pit and waste oil will be disposed to outside of the plant boundary by vacuum trucks.

Waste water from demineralized water system and chemical waste water will be collected in neutralization pit in water treatment area.

HRSG blow down will be flashed in atmospheric blowdown tanks and its condensate will be collected in blowdown pits. The collected water will be delivered to the Neutralization pit.

Treated water from neutralization it is collected in waste water holding basin and then to final check basin. Sampling test of the treated waste water and live check of pH is done before discharge the treated waste water to the river.

Storm water in the oily region shall be routed through the oil separator. Storm water other than the oily region shall be drained to the river.

Sanitary waste water from the buildings will be collected in the septic tank for each building and delivered to the swage treatment package. The treated water will be transferred to the waste water holding pond.

(g) Compressed Air System

Compressed air system will produce service air and instrument air required for the power station. Typical major components of the auxiliary steam system are as follows;

- station air compressors
- wet compressed air receiver
- Instrument air dryers
- Instrument air receiver
- Instrument air coalescing oil filter

The station air compressors shall be air-cooled, oil free rotary screw compressors. An instrument air coalescing oil filter will be between the air compressors and an air receiver in order to provide a connection of a portable emergency air compressor in case of emergency situation.

Compressed air will be stored in the wet air receiver and distribute to service air uses as well as instrument air dryers. Service air will be supplied to the hose stations which will be located at least on top of each HRSG and in the maintenance shop. Each hose station will be equipped with a ball valve, quick disconnect fitting and a 25 meter long air hose.

The instrument air dryers shall be heatless desiccant type equipped with prefilters and afterfilters and produce instrument air. Dew point temperature downstream of the dryers shall be less than -40 deg.C at atmospheric pressure. A dew point analyzer will be in the downstream of the dryers and its signal will be sent to the plant DCS for monitoring. Instrument air will be stored in the instrument air receiver and distribute to each user from the receiver.

Instrument air shall be given demand priority. If the compressed air pressure decreases to 590 kPa, service air users shall be automatically curtailed via back-pressure regulators installed on the service air branch lines.

(h) Hydrogen Generator

Hydrogen generator will be installed in the plant to cater to the hydrogen requirement in the plant.

(5) Electrical System

Electrical System consists of the following facilities. Brief specification and descriptions are provided in the subsections shown in parentheses.

(a) Main Connection to the Grid / 400kV GIS at Nasiryah I & 400kV Cables

(b) Generator Step-up Transformers

(c) Unit Auxiliary Transformers

(d) Generator Circuit Breakers

(e) Medium Voltage Switchgears & Control Gears

(f) Low Voltage Switchgears and Control Gears

(g) Station DC and AC UPS (Uninterruptible Power Supply System)

(h) Power Distribution and Control Wirings

(i) Lighting System

(j) Communication and Data Transmission System

Reference should be made on the attached Single Line Diagram (Attachment - 8) which shows the general concept of the power generation network in Nasiryah II and interconnection with Nasiryah I.

Nasiryah II portion is shown on Fig. 5-3-4.

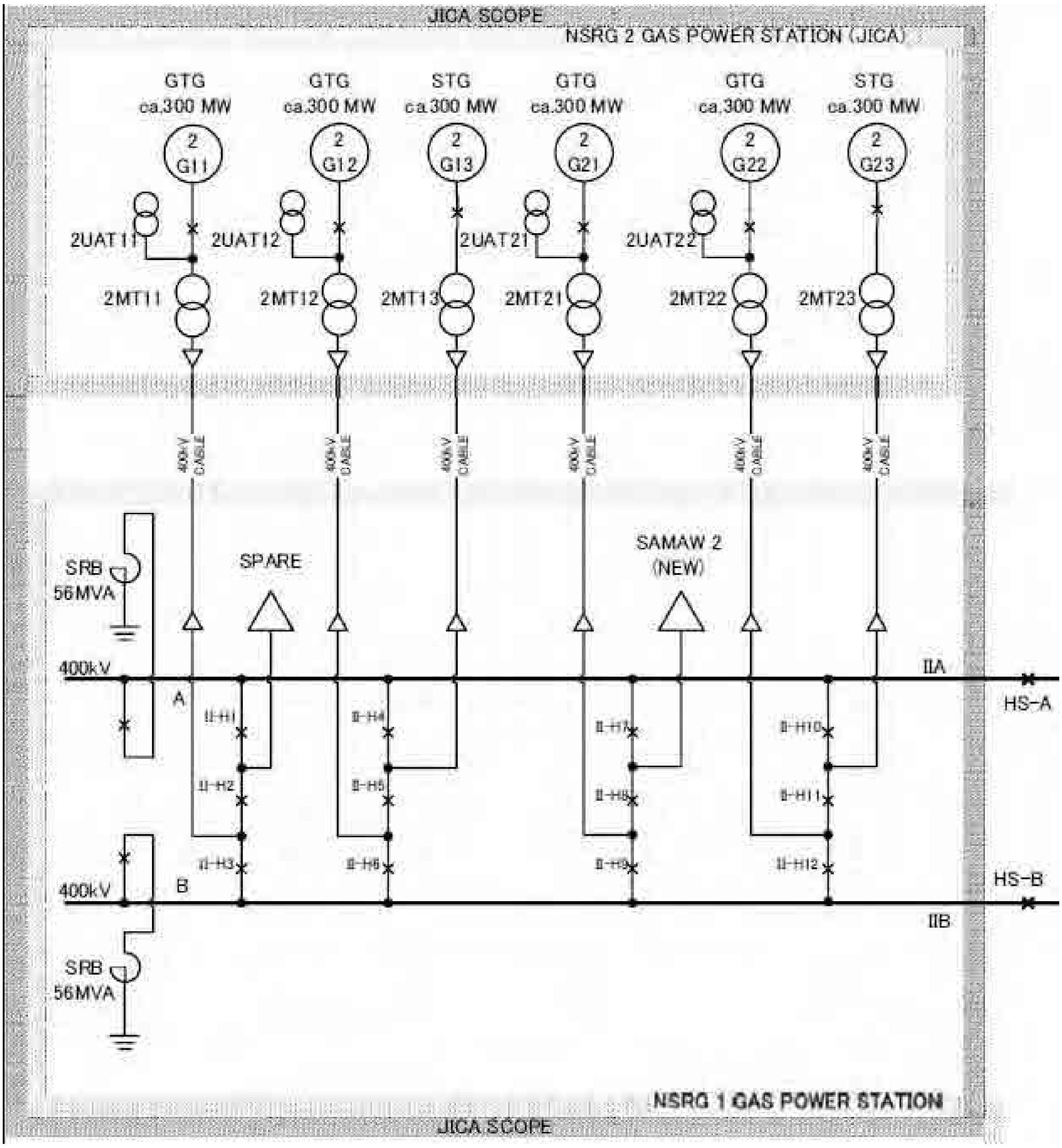


Figure 5-3-4 Single Line Diagram (Nasiryah II Portion)

(See Attachment - 8 for detail and legend)

(a) Main Connection to the Grid / 400kV GIS at Nasiryah I & 400kV Cables

1) 400kV GIS (Nasiryah I GIS Building)

Nasiryah I Gas Turbine Power Plant should be provided by others with a GIS line-up of 1-1/2 circuit breaker configuration, and the GIS main buses are extendable for connection from Nasiryah II Gas Turbine Power Plant. Nasiryah I should provide a bus sectionalizer circuit breaker on each so that no power outage is required during the main busbar extension construction by Nasiryah II project. The Nasiryah I GIS main busbar ratings shall be sufficient for both Nasiryah I and Nasiryah II Gas Power Plant and power flow through the existing transmission line cut-ins.

An interface spool of the GIS main busbar on each and all the GIS components, such as circuit breakers, disconnect switches, instrument transformers, cable terminations, etc., required for connection from Nasiryah II Gas Power Plant shall be the scope of Nasiryah II project. To cover the increased generation power by Nasiryah II, an additional overhead line connection for Samawa shall be provided in the Nasiryah II project. As a results of the number of feeders required, total four (4) 1-1/2 CB diameters (i.e., eight (8) feeders) are provided and one (1) feeder remains as spare for future use.

A fifty-six (56) MVA shunt reactor should be provided on each Nasiryah II GIS bus for compensation of the overhead transmission lines, in accordance with the MOE's request.

Nasiryah I project should provide the GIS building sufficient for their GIS and auxiliaries only, and a wall at the interface end shall be designed and constructed as removable (breakable) for extension of the building at the Nasiryah II project. Nasiryah I project overhead lines shall be so located as to leave space for the cable route from Nasiryah II for six (6) generator connections. Reference should be made on the attached Nasiryah I Conceptual Plant Layout (Attachment - 9) which is a mark up on the GE drawing 143 E 9054 Rev.G, provided by MOE. Major part is shown on Figure 5-3-5.

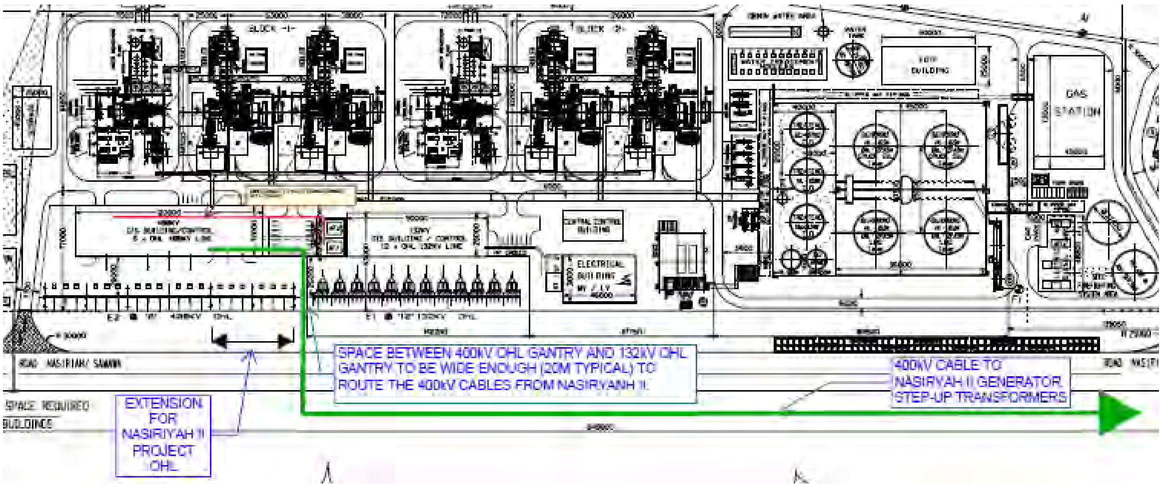


Figure 5-3-5 Nasiryah I Conceptual Plant Layout (in part)

Typical specifications for the 400kV GIS for Nasiryah II generators are as follows;-

- Operational Voltage : 400kV
- Rated Current (Bus and Bus-tie) : 4000A (Typical : To be specified by Nasiryah I project)
- Rated Current (Feeder) : 2000A (Typical)
- Rated Short Time Withstand Current : 50kA, 1 sec.

The GIS circuit breakers and the relay coordination shall be designed against the charging current for the over 2000m long 400kV cable to the Generator Step-up Transformers.

2) 400kV Cables from Nasiryah II to Nasiryah I

400kV cables shall be provided from the Generator Step-up Transformer (GSUT) in Nasiryah II to the 400kV GIS connection in Nasiryah I GIS building along the North battery limit of the Nasiryah II plant. Reference should be made on the 400kV Cable Route Plan (Figure 5-3-6).

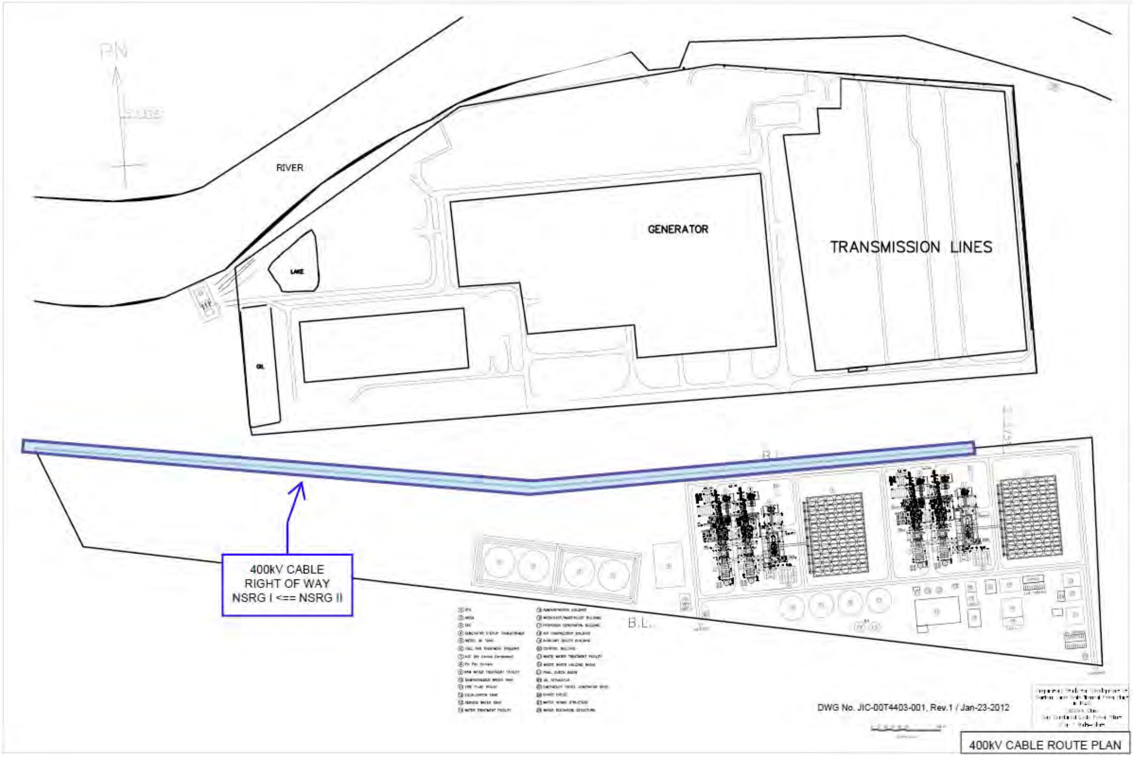


Figure 5-3-6 400kV Cable Route Plan

Two (2) rows of concrete cable trenches, to improve integrity by its inherent mechanical protection than overhead lines, should be provided, and each of them is allocated to Unit 1 and Unit 2 of the 2-on-1 GTG/STG unit respectively. Cables are hung on the cable ladder tray in the cable trench. Another reason to apply cables is the limited space available in front of Nasiryah I GIS building which receives five (5) overhead lines to other substations/power stations and six (6) generators from Nasiryah II.

(b) Generator Step-up Transformers (GSUT)

1) General

The Generator Step-up Transformers (GSUT) shall be capable to transfer the generator output in all loading situations. The ambient temperature at the plant site in Iraq shall be taken into account in the GSUT dimensioning based on the GTG and STG power generation capabilities.

2) Technical Requirements

Typical specifications for the GSUT for Nasiryah II generators are as follows;-

- Type : Oil Immersed, 2-winding, IEC60076
- Rated Voltage (HV): 400kV (Typical : To be designed according to system study)
- Rated Voltage (LV): Generator Nominal Voltage
- Rated Power [MVA] : To be designed according to system study
- Rated Frequency : 50Hz
- Cooling Type : ONAN / ONAF
- Service Condition/Location :Outdoor
- Connection (HV) : Bushing for 400kV Cable Connection
- Connection (LV) : Isolated Phase Bus Duct (IPB)

(c) Unit Auxiliary Transformers (UAT)

1) General

One (1) Unit Auxiliary Transformer (UAT) shall be connected at the IPB between the generator and the GSUT on each GTG, and capable to supply power to the MV main distribution switchgears which cover all MV and LV electrical loads for all GTGs and STG of one (1) unit. It means that the each of the two (2) UATs in the unit shall be designed as redundant transformers sized for 100% of plant auxiliary power load, so that the three (3) generators can be running even if one (1) UAT is out of service.

As a Generator Circuit Breaker is provided, the UAT covers all mode of power plant operation except emergency generator mode and no start-up transformer supplied from other power source is required.

2) Technical Requirements

Typical specifications for the UAT for Nasiryah II GTGs are as follows;-

- Type : Oil Immersed, 2-winding, IEC60076
- Rated Voltage (HV): Generator Nominal Voltage
- Rated Voltage (LV): 6.9kV
- Rated Power [MVA] : To be designed according to plant loading study
- Rated Frequency : 50Hz
- Cooling Type : ONAN
- Service Condition/Location : Outdoor
- Connection (HV) : Isolated Phase Bus Duct (IPB)
- Connection (LV) : Non-segregated Bus Duct or Cable

3) Special Consideration

The circuit breaker and the relay coordination shall be designed against the charging current for the over 2000m long 400kV cable at the high voltage side of the Generator Step-up Transformer.

(d) Generator Circuit Breakers

1) General

A circuit breaker shall be provided between the generator and the GSUT for each GTG and STG. The Generator Circuit Breaker shall be sized to the maximum output current considering all the generator operation modes of plant site ambient conditions.

2) Technical Requirements

Typical specifications for the Generator Circuit Breaker for Nasiryah II are as follows;-

- Type : Vacuum or SF6 Gas Circuit Breaker (VCB or GCB)
- Rated Voltage : To be designed as per Generator Nominal Voltage
- Rated Current : To be designed according to the maximum generator output current

3) Special Consideration

The circuit breaker and the relay coordination shall be designed against the charging current for the over 2000m long 400kV cable at the high voltage side of the Generator Step-up Transformer.

(e) Medium Voltage (MV) Switchgears & Control Gears

1) General

The MV Switchgear and Control Gear shall be provided to distribute the power from UAT to the plant loads, and it comprise of the following cubicles.

- Two (2) Incomings from both UATs in the Unit.
- One (1) Bus-tie
- Motor feeders for plant loads
- Outgoing feeders to Auxiliary Transformers

2) Technical Requirements

Typical specifications for the MV Switchgear and Control Gear for Nasiryah II are as follows;-

- Cubicle Type : Metal-clad, Indoor, IEC62271
- Circuit Breaker Type : Vacuum Circuit Breaker (VCB), Withdrawable
- Contactor Type : Vacuum Contactor, Withdrawable
- Rated Voltage : 7.2kV (Typical : To be designed as per Distribution Voltage)
- Rated Current : To be designed according to the plant loading study
- Protection Relay : Multi-function Digital Relay with monitoring and communication

(f) Low Voltage Switchgears and Control Gears

1) General

The LV Switchgear and Control Gear shall be provided to distribute the power from MV Switchgear to the plant LV loads through a Step-down Transformer, and it comprise of the following cubicles.

- Two (2) Incomings.
- One (1) Bus-tie
- Motor feeders for plant loads
- Outgoing feeders to package loads and non-motor loads

2) Technical Requirements

Typical specifications for the LV Switchgear for Nasiryah II are as follows;-

- Cubicle Type : Metal-enclosed, Indoor, IEC60439/61439
- Circuit Breaker Type : Air Circuit Breaker (ACB), Withdrawable
- Rated Voltage : 600V (Typical : To be designed as per Distribution Voltage)
- Rated Current : To be designed according to the plant loading study
- Protection Relay : Multi-function Digital Relay with monitoring and communication

Typical specifications for the LV Motor Control Center for Nasiryah II are as follows;-

- Cubicle Type : Metal-enclosed, Indoor, IEC60439/61439
- Circuit Breaker Type : Molded-case Circuit Breaker (MCCB), Withdrawable
- Rated Voltage : 600V (Typical : To be designed as per Distribution Voltage)
- Rated Current : To be designed according to the plant loading study
- Protection Relay : Multi-function Digital Relay with monitoring and communication

(g) Station DC and AC UPS (Uninterruptible Power Supply System)

1) Station DC Systems

The plant shall be provided with the following DC systems as a typical arrangement. The detail configuration shall be designed in the later stage of the project.

- 1 x 220V Battery (Lead-acid Sealed Type)
- 2 x 220V DC Power Supply
- 2 x 220V DC Distribution Board
- 2 x 24V DC Power Supply
- 2 x 24V DC Distribution Board

2) AC UPS (Uninterruptible Power Supply System)

The plant shall be provided with the following AC UPS system as a typical arrangement. The detail configuration and the output voltage shall be designed in the later stage of the project.

- 1 x Battery (Lead-acid Sealed Type)
- 1 x UPS (Single Inverter with a static-switch controlled Bypass Circuit)
- 1 x UPS Distribution Board

(h) Power Distribution and Control Wirings

MV and LV power cables shall be XLPE insulated cable with proper voltage level manufactured in accordance with IEC60502. Cables shall be capable of loading the loads to be connected and also withstanding the short circuit fault current within the protection trip period.

Cables shall be installed on the metallic cable ladder with cover, in general in the power plant, so that mechanical protection and easy access for maintenance should be provided.

(i) Lighting System

Lighting system shall provide the sufficient illumination of the plant site to enable the identification and safe operation of the equipment as well as personnel movement. Minimum number of lighting fixtures shall be allocated to achieve the energy conservation and less CO_2 emission.

Minimum Emergency lighting shall be provided to cover the personnel evacuation at the plant power shutdown.

(j) Communication and Data Transmission System

Communication systems shall be provided in Nasiryah II Power Plant so that the minimum communication should be continuously available within the plant and with the adjacent plants. Typical facilities of power plant are shown below.

- Telephone System : Internal lines and external connection to public network
- Hot-line Telephone System : Dedicated communication with Nasiryah I Control Room
- Paging System : Plant internal communication among operators and maintenance staff
- Remote Terminal Unit/Module for Data Transmission with Nasiryah I (If necessary)
- Optic Fiber Connection : Control and Protection Data Transfer and Personnel communication
- UPS for Communication System

(6) Control and Instrumentation

(a) General Concept

The control system concept shall be based on the following main requirements:

- Maximum safety for personnel and equipment
- Safe, reliable and efficient operation
- High availability of the power plant
- High quality of design extensively proven

The overall Distributed Control System DCS will be provided for the whole power producing process including its sub-systems and BOP (Balance Of Plant) areas. The gas turbine and steam turbine may be supplied with the supplies standard autonomous control system. When the dedicated control system is provided, the system will be interfaced with DCS to transmit the required signals.

The single failure criteria will be applied throughout the entire DCS design. This means that a single failure in any part of DCS will not lead to a trip a plant of main component, e.g. gas turbine, steam turbine, generator, etc. All open and closed loop control systems will be based on DCS with built-in redundancy and will be interconnected via a redundant high speed bus system. For the gas turbine and steam turbine generator, water treatment package, instrument air package, etc. however, this redundancy concept will be based on the package vendor own standard.

For the DCS, the operator will obtain the complete information on 20” LCD at the Human Machine Interface (HMI) in the control building such as:

- Operation and status of the plant
- Operation and status of each and every component and sub-system
- Critical operating condition
- Failure of process equipment, components and / or systems
- Each fault, abnormal or critical condition will be clearly indicated, in order to avoid ambiguity and to reduce time for remedial actions
- Trend, logs, long term data storage, historical data analyzing, plant performance monitoring, alarm and event display
- Diagnostic information of the DCS equipment

Hardwired trip push button for the gas turbine and for the steam turbine will be provided in control room. The number of different DCS hardware devices will be limited to a reasonable number.

(b) DCS (Distributed Control System)

DCS will be a complete modern and field proven system. The DCS is intended to be a fully integrated system with process control stations, operator stations with LCD 20” screens as HMI, a high speed communication network, and an engineering station. Plant control system configuration is shown in Attachment - 10.

In general, DCS will perform the following main function.

- Power plant controls
- BOP process controls
- Operation, monitoring and supervision
- Data acquisition system for management applications
- Engineering and documentation

The interface between the plant DCS and the dedicated package control system (PLC base) will be via field proven communication system (e.g. Modbus). However, critical signals such as trip command will be hardwired.

The CPU of the process control stations will be redundant with automatic bump-less changeover. Process control stations will have non-volatile memory for fail safe storage of control application programs, graphics, etc. The time tagging of all Sequence of Events Recording (SER) signals will be done at the field input into the DCS, i.e. at the input modules. The required time resolution will be 1ms. Time accuracy and resolution of 1ms will be at least available for SER operation of generator breakers, protective relays, turbine trips, HRSG trips and other critical facility functions. This SER-functionality will be completely integrated in the DCS. The recording and log will be fully configured in the DCS. The following signals or changes of state will be logged by SER as a minimum.

- Trip alarm
- Measurement diagnostic status (e.g. out of range)
- Maintenance override
- Input force status
- DCS hardware / utility alarm
- Operator acknowledgement

Input / output module will have extended diagnostic capability. The diagnostic will include channel-related fault display, internal module monitoring, diagnostic alarms, storage of last value or connection of a default value on failure of the CPU or load power supply. The input/output modules will be able to detect open-circuit, short-circuit, module internal faults, and to signal automatically these alarms to the operator station respectively to the engineering station.

In order to achieve high system availability, the following equipment will be redundant:

- Communication data highway
- Process controller (central processing unit)
- Operator station
- Power supply
- Input/output modules for all the critical plant signals
- Serial links with critical sub-system

DCS will be designed with the following spare capacity as minimum so that future expansion can take place without the need of additional hardware after commissioning;

- I/O modules	20% wired for all types
- Terminal blocks	20% wired for all types
- Rack space of marshaling cabinet	20%
- Slot space within racks	15% of slots used
- Power supply	25% above the peak load

For DCS loading criteria, DCS shall be designed with the following capacity after commissioning as maximum so that future expansion can take place without the need for additional hardware after commissioning;

- CPU including memory	60%
- I/O capacity and other hardware	60%
- Communication network	50%

The typical DCS equipment in control room includes but is not limited to:

- Four (4) sets of operator stations, each equipped with 2 x 20” flat LCD display, keyboard, mouse or track ball
- One (1) supervisor operator station, equipped with 20” LCD display, keyboard, mouse or track ball
- Two (2) black/white laser printers and 1 color laser printer for display hardcopy
- One (1) engineering workstation with a color printer
- One (1) Emergency stop pushbutton panel (ESD) panel
- Desk for operator stations, printers, etc.

All controllers, input/output modules, network communication modules, terminal boards, tec., will be mounted in cabinets which are installed in air-conditioned control room. All cabinets will have a uniform appearance in height and color. All wiring inside cabinets will run in dedicated plastic duct / trunk. Loose wiring is not allowed. All the cable entries will be through bottom plate only with suitable bar strips / cable glands. Access to cabinets will be from front and rear full length hinged removable, lockable doors.

Engineering workstation will be capable as the following function;

- Database configuration including overview, group, loop, multi loop and multi-variable control configuration.

- Group or multi-group alarm inhibit from the plant under maintenance
- Tuning of control loops
- Compilation of graphic displays
- Compilation of logs/reports/historical trend points.

For DCS software function, computational algorithms such as addition, subtraction, multiplication, division, averaging, square root, ramp, rate of rise/fall will be provided as a minimum. Sequential, complex loops, timed and computational control program will be supported via a high level programming language. The system will support logic control program where the grouping/linking of various logic functions will provide the required functionality. The system will allow for transfer of control signal (PV, calculations, etc.) from any of the distributed processor on the network to allow for interruption of unit controls into the overall plant control.

DCS clock shall be regularly synchronized by an external master GPS clock synchronization unit to communicate in real time in the data transmission and reception with all the other applicable system via network.

(c) Field Instrumentation

Field devices from reputable manufacturer will be applied as far as possible.

Standard range for analog signal will be 4-20 mA. Smart type transmitter with HART protocol will be applied. The operation voltage of instruments connected to the control systems will be 24VDC. The electric signal transmission will normally be a two (2) wire systems. The use of three (3) or four (4) wire system will be limited. Pneumatic standard signals will be 20 to 100kPag (0.2 to 1.0 barg). Proximity signals will be in accordance with NAMUR. Digital signals may be applied either as potential free inputs or as DC powered outputs. Other signals and/or the application of specific signal type such as vibration monitoring, pulsed flow or speed signals, motor operated valves (MOV) systems etc. may be required and will be defined in accordance with the manufacturer’s recommendation.

All transmitters will be provided with a local indicator (e.g. LCD display type). All instruments will be factory calibrated and it will be possible to re-calibrate and configure with a field calibration tool such as a hand-held HART communicator.

For all indicated values, units of the System International (SI) of weights and measurements will used. Position indications of final control element will be graduated in percentage.

Instruments will be selected generally in such a method that the normal working point of the instrument is between 50% and 75% of the instrument range.

Binary switch instruments, e.g. pressure switch will be replaced as far as possible by analog transmitters.

All enclosures shall be protected against ingress according to minimum IP56 of IEC61529 for outdoor installation, or minimum IP42 of IEC61529 for indoor installation.

Local indicating instruments will be circular, with a minimum 4”(100mm) dial size. Smaller size will only be provided where it is not practical to meet the requirement.

All equipment and systems for the plant will be provided with their necessary taps for pressure, temperatures (thermowell), level and flow in order to carry out performance test.

Control valves, on-off valves and accessories will meet the functional requirement outlined in relevant codes, standards and manufacturers manuals to enable the correct operation and service. The control valves and on-off valves will be designed or their intended process duty and also for the environmental condition of the plant area where are to be installed in. The valves will be sized using their manufacturing's sizing program. Pneumatic actuators will be single/double type, with digital based electro-pneumatic positioners having 4-20mA HART compatible inputs.

The location of instruments and control valves will permit easy access from grade, permanent platforms or stairways for easy operation, inspection and maintenance. The use of portable ladder or mobile platform will be limited to access root valves, thermowells, and lime mounted flowmeters. Locations will be decided to minimize the possibility of damage from passing or falling objects and the possibility of tripping hazard or obstruct on walkway.

(d) Continuous Emission Monitoring System

Each of the HRSGs will be provided with a complete set of Continuous Emission Monitoring System (CEMS). As a minimum, the following emission values will be measured, calculated, and recorded:

- Oxygen (O2)
- Nitrogen oxides (NOx),
- Sulfur dioxide (SO2)
- Carbon monoxide (CO)
- Particular matter (PM)
- Flue gas flow

The data transmission from every single analyzer to the data acquisition station will be by means of hardwired analog signal (4-20mA) and contacts for status / alarm signals.

The emission data, received from analyzer equipment via the data acquisition station, will be calculated and converted into the required values in the emission monitoring systems. Its software will be especially designed for emission evaluation purpose. Reports will be printed periodically or on demand on its dedicated printers.

The opacity measurement device will provide continuous monitoring of the particulate contend in flue gases. The device will be suitable for in-site measurements and will be have a response which is immediate, stable and unaffected by weather conditions, daylight or darkness. The device will have a compact design and will be suitable for an easy installation on the HRSG stack. The device will be interfaced with the plant DCS via suitable serial interface. All the measured emission data will be available in the DCS system as backup.

(e) Operator Training Simulator (OTS)

The complete set of operator training simulator (OTS) will be provided to familiarize operators with a new and complex process. The hardware of OTS will consist of four (4) trainee stations, one (1) instructor station, color printer, simulator, and required network connections as a minimum. The OTS will be PC base system. The appearance of OTS trainee / instructor station will be same as DCS operator station.

For software, dynamic simulator with usage license and customized process model will be provided. The simulator requirements will be that all major mechanical and electrical systems within the Nasiryah II power plant and the related GIS be simulated.

(7) Civil

(a) Location of Project site

The Project site is located approximately 340 km southeast from Baghdad. The site is situated the right bank approximately 127 km of upstream to the Euphrates River from Nasiryah City, and adjacent to south boundary of the existing Nasiryah Thermal Power Plant. The ownership of the project site has retained by Ministry of Electricity. At present, there is no significant structure and economic activity performed in the area.

The railway from Baghdad to Basra runs along the south boundary of the project site.

(b) Land reclamation and design ground level

The project site has unlevelized ground having some irregularity across the area. The Project site should be situated on the same level as the existing Nasiryah TPP at EL+6.0 m. Meanwhile, the project site is surrounded by the dike of Euphrates River and the existing switch yard both which are situated on E.L. +7.0 to 8.0m.

Therefore, some earth works for land reclamation are required to raise the ground surface leveling with the surrounding lands. For embankment works, MOE has selected a borrow pit that is located 12km northwest from the project site along Nasiryah-Samawa road. At present, the borrow pit is commercially operated for producing sands for road construction works. MOE mentioned that it has enough capacity to provide sands to the Project site.

1) Execution scheme of land reclamation work is as following;

a) Experiment banking test
- Analysis of banking material [grain size, water content]
- Experiment banking test Strip top soil
  [Spread depth, Number of rolling coverage, Quality Control Test (density test)]

b) Banking
- Remove surface layer with existing scrap and tree
- Mixing soil material (if need)
- Spreading soil [Spreading depth less than 0.3m]
- Rolling, Compaction [Number of rolling coverage]
- Compaction test [ex] density test]

(c) Geological

The soil with N-vales 10 to 15 is situated in the shallow layer near the ground surface. This can support minor facilities having small loads by adopting direct foundations. The bearing layer for medium and large load structures is situated in GL-13 to 15m. Pile foundation is adopted for the large and medium load structures.

Detail geological conditions are shown in the Section 5.2.2 (5).

(d) Seismic criteria

Seismic Code:	UBC97
Seismic importance factor	1
Basic Seismic Coefficient	0.2 g

(e) Foundation Structure

Both proper designing and well-supervised construction are necessary to retain foundation structures stable and safe. Considering the site conditions, the soil properties, the type of the structures, the loading distribution and the in-situ test results, it was found that piling works needed to be considered as one of the most reliable foundations assuming that design loads exceeds the allowable bearing capacity of the subsoil stratum. The piling works are performed by using technologies such as driven precast or bored piles.

In the designing of piles, the ultimate bearing capacity of the pile should be determined in consideration of the ultimate resistance of the end of pile (end bearing) and skin friction. Those parameters are estimated by using the results from the lab test and in-situ standard penetration test.

For medium load structures such as tanks, precast driven pile (28.5 x 28.5cm) is well workable by utilizing medium clayey layer near the ground surface as a soil foundation.

However the maximum pile length for heavy load supporting could be calculated in line with the results from in-situ standard penetration tests as well as the weakest soil profile and lowest strength parameters through the layers.

The structures can be supported by pile foundation which bottom end is situated 12.0-14.0m deep from the ground surface when those have medium and heavy loads. Allowable bearing capacities of each type of piles are shown in Table 5-3-4.

Table 5-3-4 Allowable bearing capacity of each Pile

Pile type	Dimensions (cm X cm), Ø (m)	Length (m)	Allowable bearing capacity (Tons)
Precast Driven Concrete Pile	28.5 X 28.5	12.0-14.0	30-40
Bored RC Pile	Ø0.8	12.0-14.0	80-100
	Ø1.0		95-115

On the top of that, additional loads such as negative and/or positive skin friction need to be taken into consideration to appropriately define the specification of pile foundation. To determine accurately the pile length and capacity, it is worth considering that field pile loading tests should be carried out at different three locations at least.

For the raft foundation, it is estimated that the allowable net soil bearing capacity can be retained at 75 to 85kPa in the layer situated at the depth of 1.5 to 2.5m and the shallower layer well compacted at the depth of 0.5 to 1.0m.

Eventually, the safety factor was evaluated to be 2.5 to 3 based upon the above mentioned soil conditions and the designing of piles. The differential settlement is expected to be about 50% of the total settlement across the project site.

At the detail design stage, the technical requirements of the foundation structures need to be clearly defined in consideration of the actual soil conditions. Thereby, supplemental foundation works such as accelerating consolidation method and soil improvement work can be appropriately prepared.

(f) Intake and Screen Pump pit

For intake system, the surface intake system can be adopted with the following conditions:

- Water depth is a comparatively shallow.
- Intake water volume is low.

Screen pump pit consists of 2 lines with 2 stage screen equipment and grit chamber because Euphrates River has high SS, river algae and jetsam.

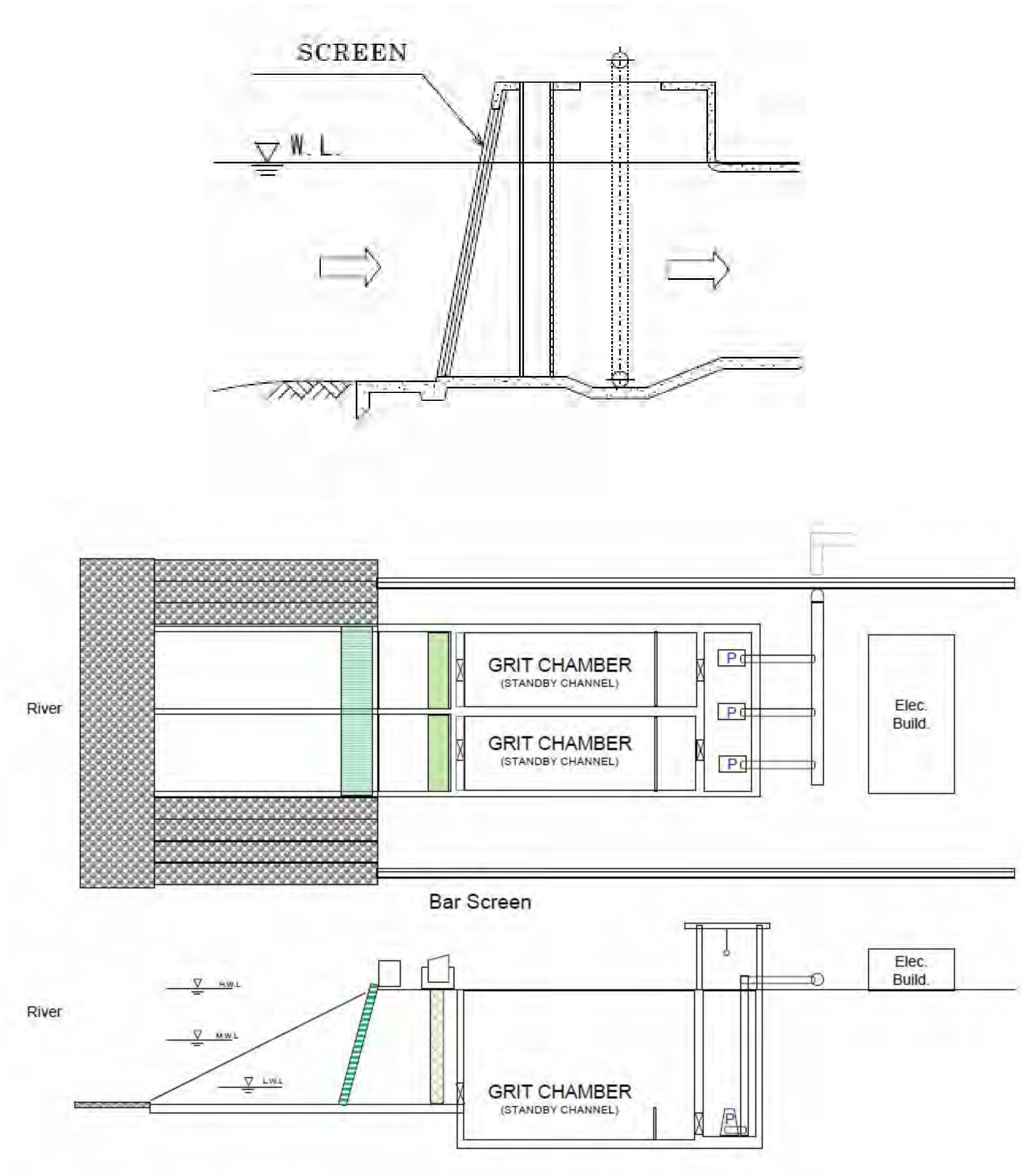


Figure 5-3-7 Intake and Screen pit

Three sets of circulating water pumps (50% capacity × 3 sets) are installed.

It is recommended that the type of the pump pit should be studied based on reliable design standards such as the standard of the Japan Society of Mechanical Engineers (S004-1984: Model Test Method of Pump Pit).

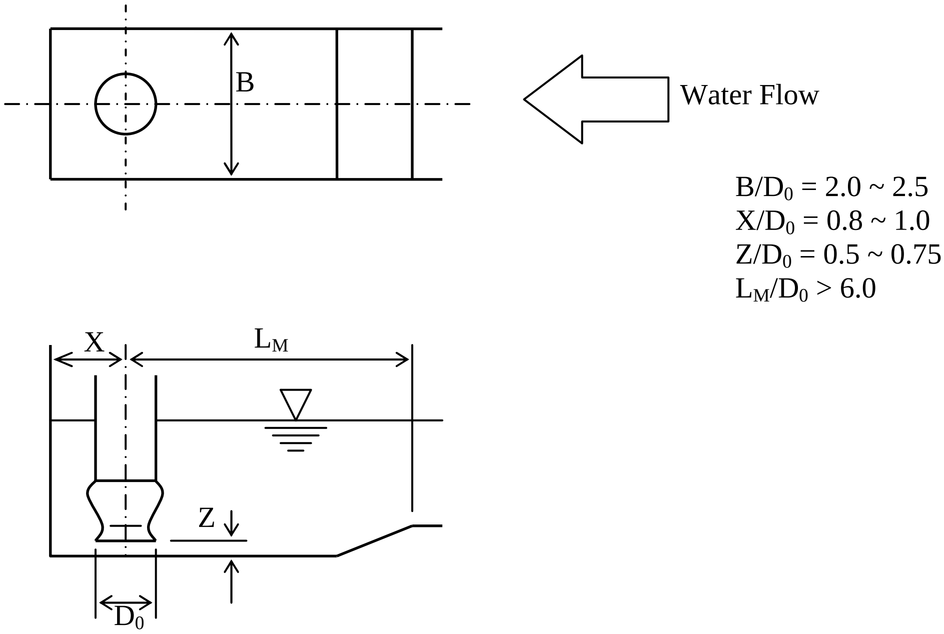


Figure 5-3-8　Standard Form and Dimension for Pump Pit

(g) Waste water discharge system

Reject water from the river water pre-treatment facility has high salinity content. Even though the amount of such waste water is not so large, diffuse discharge into the river needs to be considered to mitigate impacts on downstream water use and environment because the flow velocity of Euphrates River is slow in the vicinity of Nasiryah II project site. A submerged multi-nozzle type discharge system is possible to perform high discharge velocity and diffusion.

(h) Surface water drainage system

Surface water drainage system consists of gutters and surrounding check pits mainly gathering rain water. Discharging surface water to the river should be performed after the checking of water quality.

5.3.4 Project Cost Estimate and Cash Planning [Non-Disclosure]

5.3.5 Procurement and Transportation Schedule of Equipment

In the large scale gas fired combined cycle thermal power plant project like Nasiryah II, major items critical to procurement and transportation schedule are as follows.

- Gas Turbine Generators (GTGs)
- Steam Turbine Generators (STGs)
- Heat Recovery Steam Generators (HRSGs)

And sub-critical items will be as follows.

- Air Cooled Condensers (ACCs)
- Generator Step Up Transformers (GSUTs)
- 400kV Substation

From time schedule view point, these major items are often called as long lead time items (LLIs).

Almost all major items will be imported from overseas such as Japan, Europe, USA and so on. Marine transportation will mostly be similar to and not so different from those of other international power projects.

Inland transportations are required for major items to the Nasiryah II site from applicable ports. Many of major items will be very large and/or heavy and be transported as over dimension cargos (ODCs). Inland ODC transportation will need special cargo machines, longer time periods and special set ups along traveling routes such as reinforcement of .bridges. Barge transportation through Euphrates River will not be applicable because of decreased level of water.

Inland transportation in Iraq will also be evaluated for the security concerns. Because of its larger size and slower movement, ODCs should be prepared carefully for the security provisions and programs.

One of critical path in the early stage of the project will be the EPC of civil (foundation) works relating to major items. Civil design should be based on the civil information from equipment suppliers. It will be essential for the schedule to acquire the civil information of major items as early as possible after PO to make foundations ready before or at the time of delivery of equipment to the site..

Preliminary project months of procurement and transportation milestones of LLIs are shown as reference in Table 5-3-6. Project months assume EOC as the 0 (zero) point of time.

Table 5-3-6 Procurement and Transportation Schedule for reference

	ITEM	PO	FOB	Landing	On Site	NOTES
1	GTG	0^{th} Mo	10^{th} Mo	12^{th} Mo	13^{th} Mo	
2	STG	1^{st} Mo	18^{th} Mo	20^{th} Mo	21^{th} Mo	
3	HRSG	1^{st} Mo	16^{th} – 20^{th} Mo	18^{th} – 22^{nd} Mo	19^{th} – 23^{rd} Mo	Phased delivery
4	ACC	1^{st} Mo	15^{th} – 18^{th} Mo	17^{th} – 20^{th} Mo	18^{th} – 21^{st} Mo	Phased delivery
5	GSUT	1^{st} Mo	15^{th} Mo	17^{th} Mo	18^{th} Mo	
6	400kV Substation	1^{st} Mo	9^{th} Mo	11^{th} Mo	12^{th} Mo	

(1) Gas Turbine Generators

CCTPP train of Nasiryah II will be commissioned in two steps. On the first step, to moderate the situation of electric power deficiency in Iraq, GTGs will be commissioned in simple cycle mode earlier than the next step of entire combined cycle commissioning.

Procurement and transportation schedule is critically essential to achieve early commissioning of simple cycle operation. The purchase order (PO) of gas turbine generators should be placed as soon as possible preferably almost immediately with the effectuation of the EPC Contract (EOC) or notice to proceed (NTP) to the EPC Contractor.

(2) Steam Turbine Generators

Steam turbines probably need the longest fabrication period among all CCTPP installations. STG fabrication periods will also vary case by case more significantly than GTG. It is not unusual that the STG procurement becomes the most serious critical path in the entire CCTPP project schedule. In many projects, even early release of suppliers before EOC is required for steam turbines to keep the schedule

The situation is a little bit different for Nasiryah II which applies 2 (two) steps commissioning as stated above. However STG should still be one of most critical items to be carefully managed in procurement and transportation schedule. PO of STG will preferably be placed as early as possible to keep commissioning date.

(3) Heat Recovery Steam Generators

HRSGs are items required for the second step of commissioning of Nasiryah II similarly to STGs.

PO of STG will preferably be placed as early as possible too. In addition, HRSGs will be delivered in several separate steps such as steel structure, pressure parts and accessories. These steps should be well coordinated with the erection schedule.

(4) Air Cooled Condensers

ACCs have relatively simple construction repeated for many identical modules. However the size and material quantities of total ACC system are so large in total that erection work at site needs very long time periods. ACCs will potentially be another critical item to combined cycle to be procured and transported as LLI.

Cargo size of ACC will depend on the modularization applicable. To reduce the on site erection work, extensive modularization is advantageous though too large modules will be disadvantageous for transportation. Careful tradeoff between erection and transportation will be requested for optimization of the project.

(5) Generator Step up Transformers

Fabrication time of GSUT could vary case by case and/or supplier by supplier in general. Especially for Nasiryah II which will be commissioned earlier with simple cycle mode, procurement and transportation schedule should be very critical for GSUTs of GTGs.

GSUT will also be critical to the commissioning schedule where commissioning power will be backfed from the transmission grid through GSUT and UAT. In such case GSUT needs to be commissioned earlier than GTG.

GSUTs are one of the heaviest items and may exceed 350 tones per unit. Transportation of GSUT should be evaluated carefully in ODC transportation planning.

(6) 400kV Substation

400kV substation will be required to be commissioned earlier than GTGs if the commissioning backfeed power will be supplied from the transmission grid through 400kV substation similar to GSUT.

5.3.6 Overall Construction Schedule

Figure 5-3-10 shows the conceptual EPC (engineering, procurement and construction) schedule for Nasiryah II CCTPP project. It should be noted the schedule shown for one CCTPP train only. EPC of the 2nd train will follow after the 1st train with certain interval such as 6 months.

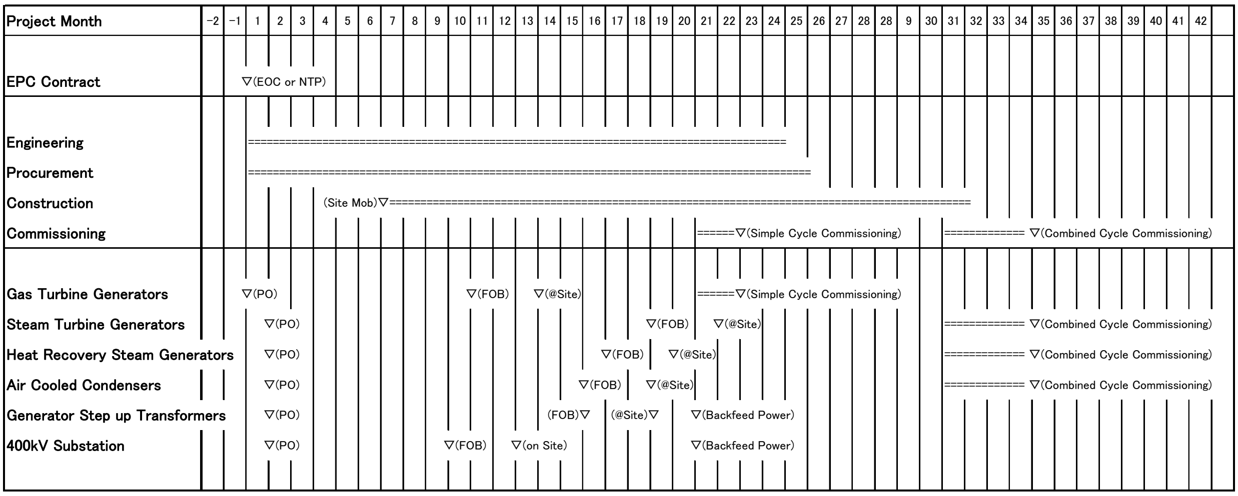


Figure 5-3-10 Conceptual EPC Schedule for Nasiryah II CCTPP for reference

(1) EPC Schedule

Construction Schedule should be developed and executed together with engineering and procurement schedules. To have successful project and achieve the anticipated commercial operation date, EPC integrated schedule approach must be applied.

(2) Phasing Constriction Approach

Nasiryah II CCTPP project consists of 2 (two) combined cycle trains as the power blocks. Both trains are basically identical each other and take 2 on 1 type shafts arrangement which consists of 2 (two) GTGs, 2 (two) HRSGs and 1 (one) STG. In the large scale multi trains thermal power plant construction projects such as Nasiryah II, phasing construction is commonly applied as the practical approach. Entire Nasiryah II project will be separated into two phases of Phase 1 and Phase 2. Each phase dedicates to one train. Interval between two phases will be determined accordingly to the relating conditions such as financial affairs, power demands, transmission capacity, fuel supply, construction resources and so on.

(3) Early Simple Cycle Commissioning

Nasiryah II CCTPP will be operable in either combined cycle mode or simple cycle mode using bypass damper and stack installation. To take advantage of this flexibility for mitigating the tight situation of electric power supply in Iraq, early completion and commissioning of simple cycle will be applied. Construction of combined cycle portion such as STG, HRSG and ACC will be continued for the following commissioning of the entire combined cycle.

5.4 Environment and Social Considerations

5.4.1 Review of Existing Study Reports and List up of Study Items

(1) Basic concept of the environmental and social considerations

The Study Team implements environmental and social considerations for the Project and assists the MOE to prepare an Environmental Impact Assessment (EIA) report for the construction of the thermal power plant at the identified Feasibility Study site under “the JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002)”. The following concepts are considered important to implement the environmental and social considerations for the Project.

- Alternatives and mitigation measures are proposed to avoid and minimize negative impacts induced by the Project.
- It is necessary to plan the Project from all aspects to reconcile economical, financial, institutional, social and technical needs.
- Results of the environmental and social considerations are documented and disclosed to the public.

Based on the above-mentioned important concepts of the environmental and social considerations, the following five points are identified to collect, analyze and evaluate data.

(a) Compliance with the Iraqi laws and standards

Environmental studies are planned and conducted under the Iraqi laws and standards related to environmental considerations.

(b) Acquisition of social consensus

The Study Team adequately consults with all related stakeholders to acquire appropriate social consensus on the Project. The Study Team works closely with the MOE, MOO and the Ministry of Environment to discuss and plan the details of the Study. Regarding the disclosure of information, it is necessary to take it into account that there are social issues such as the Arabic culture, the socially vulnerable and the literacy rate, and to work closely with the counterparts for taking appropriate steps not to confuse the local people.

(c) Considerations on biodiversity

The Study Team well understands the importance of the ecosystems and their fauna and flora in southern part of Iraq, and conducts the appropriate environmental considerations. The Study Team collects information on these biodiversity from international NGOs such as BirdLife International and IUCN and national NGO such as Nature Iraq.

(d) Considerations on the socially vulnerable people

It is necessary to take appropriate considerations on the socially vulnerable people such as elderly people, women, children and ethnic groups (e.g. Marsh Arabs) in close consultation with the local governments.

(e) Minimization of impacts caused by involuntary resettlement

The Project avoids and minimizes involuntary resettlement and its impacts such as loss of livelihood. According to the Pre-Feasibility Study (2007 – 2008), involuntary resettlement is limited in these identified sites if it occurs. The Study Team conducts the survey and confirms the current statuses in these sites in close collaboration with MOE.

(2) Review of the Existing Study Reports

The Existing Study Reports are reviewed and studied to collect information and data for an efficient implementation of the environmental and social considerations. The Study Reports are categorized in the following three groups, and the reviewed reports are list in each group.

(a) Environmental Impact Assessment reports and other F/S Study reports

- Large Scale Thermal Power Plant Site Selection Study in Southern Iraq (2008)
- Rehabilitation of the Hartha Power Plant in Basra (Iraq) - Environmental and Social Impact Assessment (2009)
- Baiji Refinery Upgrading Project – Preliminary Environmental and Social Impact Assessment (2010)
- Environmental Impact Assessment – Upgrading FCC Project Of Basrah Oil Refinery (2011)

(b) Natural environment

- Iraq Fourth National Report to the Convention on Biological Diversity (2010)
- Important Bird Areas in the Middle East (BirdLife International, 1994)
- The Mesopotamian Marshlands: Demise of an Ecosystem (UNEP, 2001)
- WWF website as follow:
  Tigris-Euphrates alluvial salt marsh (PA0906)
  http://www.worldwildlife.org/wildworld/profiles/terrestrial/pa/pa0906_full.html
  Mesopotamian Delta and Marshes
  http://wwf.panda.org/about_our_earth/ecoregions/mesopotamian_delta_marshes.cfm
- Ramsar Convention Bureau website as follows:
  The Annotated Ramsar List of Wetlands of International Importance: IRAQ
  http://www.ramsar.org/cda/en/ramsar-junefrontpage/main/ramsar/1%5E25129_4000_0_
- IUCN website as follows:
  The IUCN Red List of Threatened Species
  http://www.iucnredlist.org/

(c) Social environment

- Environment in Iraq: UNEP Progress Report (2003)
- UNESCO website as follows:
  UNESCO World Heritage Centre
  http://whc.unesco.org/en/list

(3) List of Study Items

Based on the review of the Existing Study Reports and the profile of the Project, the following study items are listed to collect basic data on environmental and social statuses.

(a) Related laws and procedures, related institutions and organizations

The related laws and procedures, and the status of the related institutions and organizations are reviewed by literature and internet surveys. The following items are studied:

- Legislation, criteria / standards, procedures, and functions of the governmental bodies and agencies, concerning the environmental issues, such as EIA, air and water quality, expropriation of land and resettlement, participation of residents, labor conditions and disclosure of information; and

- The functions and administrative capabilities of the said governmental bodies and agencies.

(b) Physical environment

Air quality, noise, topography, geology & soil, meteorology (e.g. temperature, precipitation, wind), hydrology (e.g. river water flow, underground water, floods), information on earthquakes (e.g. location of faults)

(c) Natural environment

Protected areas (e.g. proposed Mesopotamian Marshlands National Park and Hawizeh Ramsar wetland), important ecosystems identified by international NGOs, wetland ecosystems (i.e. Mesopotamian Marshlands), fauna and flora (especially endangered species)

(d) Social environment

Administrative boundaries, regional development plan, social and economic situation (e.g. demographic status, industrial structure), land use and land tenure, existing infrastructures (e.g. road, bridge), transport, historical/ archeological / cultural heritages, status of the socially vulnerable.

5.4.2 Legislation and Standards

(1) Policies on environmental issues

"Iraq: National Development Plan 2010-2014 (Ministry of Planning, 2010)" sets a vision on the environmental issues as following:

> Protecting the environment and tackling sources of environmental pollution by planning a sound environmental management approach aimed at transforming the approach to dealing with natural resources to a more sustainable one that preserves biological diversity, raises environmental awareness, and promotes the principle of environmental citizenship to achieve the Millennium Development Goals.

To pursue the vision, there are two goals to be achieved:

First Goal: Promoting Sustainable Development
Means of achieving the objective:

1. Adopting defined and environmentally sustainable investment projects that various ministries, local communities, federal and regional governments participate in selecting.
2. Instituting a special system for environmental impact assessment in Iraq to ensure that investment projects included in the development plan meet environmental requirements and specifications.
3. Reinforcing international cooperation through signing environmental agreements with neighboring countries to protect the environment, as well as joining international environmental conventions.

Second Goal: Monitoring the Environmental Reality
Means of achieving the objective:

1. Developing an integrated system for environmental monitoring, evaluation, and follow-up.
2. Monitoring the types and sources of pollution and measuring them against national and

international standards.

3. Importing and developing devices for measuring pollutants for follow-up and analysis purposes.
4. Promulgating a set of environmental legislations that include laws, regulations, instructions and environmental standards aimed at protecting and improving the environment and preventing pollution so as to match global developments in this area.
5. Using environment-friendly technology in addressing sources that threaten the environment, especially solid waste.

(2) Legislation on Environmental Impact Assessment

(a) Ministry of Environment

Coalition Provisional Authority issued the Order No. 44 in November 2003 establishing the Ministry of Environment (MOEN) to protect and conserve the Iraq's environment for the people of Iraq. MOEN is responsible for protecting and conserving the environment in a view of harmonizing other sectors' development and for implementing its functions by developing policies, running environmental programs and promulgating and enforcing standards[16].

The organization structure of the MOEN to carry out its functions was approved in October 2008 as shown in Figure 5-4-1. Under the Technical Directorate shaded in Figure 5-4-1, there is Environmental Impact Assessment and Land Use Department[17].

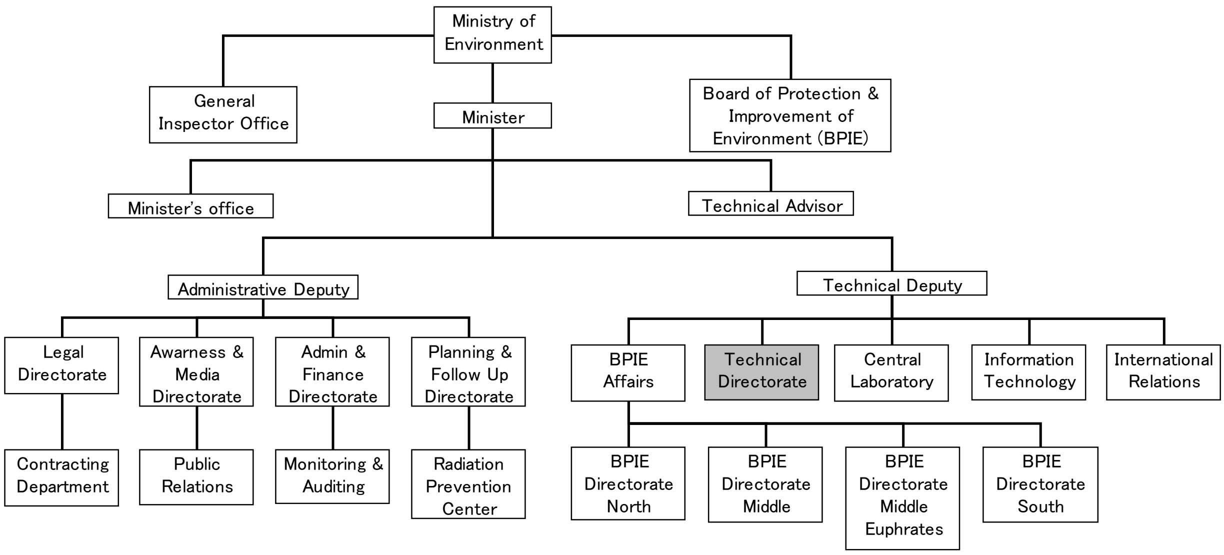


Figure 5-4-1 Organization Structure of MOEN[18]

[16] Iraq Institutional Capacity Assessment Report (UNEP, 2006). In 2008, Law No. 37 formally established the Ministry of Environment.

[17] From the presentation material by MOEN at United Nations Economic Commission for Europe MOS 3 in November 2010.

[18] Modified from the organization chart shown in "Iraqi Fourth National Report to the Convention on Biological Diversity (2010)"

➢ Regional Directorates and Local Units of MOEN

Each provincial MOEN under Board of Protection and Improvement of Environment (BPIE) Directorates (e.g. BPIE Directorate South) consists generally of the following units:

- Air Quality Monitoring Unit
- Water (Natural Sources and Drinking) Monitoring Unit
- Solid Waste and Chemical Hazardous Management Unit
- Biodiversity Unit
- Marshlands Unit
- EIA Unit
- Desertification and Land Use Unit
- Industrial Activities Monitoring Unit

Each Directorate in the governorate contains the above-mentioned units, and special units connected with the deputy minister:

- Sustainable Development,
- Clean and Alternative Energy,
- New and Environmentally Friendly Technologies Unit.

The former MOEN of the Kurdistan Region had three main Governorate Directorates (Dohuk, Erbil and Sulaimaniya). The status of these offices is not known.

➢ National committees

The following six (6) national committees are managed by the MOEN:

- National Committee for Protected Areas
- National Committee for Biological Diversity
- National Committee for Ozone
- National Committee for Ramsar[19]
- National Committee for Climate change
- National Committee for RERAG

(b) Environmental Impact Assessment[20]

The Law on Environmental Protection and Improvement (No. 29 of 2009) is the primary environmental legislation in Iraq. Chapter 4 of the law specifies a number of detailed provisions with which projects must comply.

Article 10 (Chapter 4) of the law states the Environmental Impact Assessment (EIA) report as in the following box.

19 "Convention on Wetlands of International Importance Especially as Waterfowl Habitats" is usually called as "Ramsar Convention on Wetlands".

20 From the presentation material by MOEN at United Nations Economic Commission for Europe MOS 3 in November 2010.

I. The owner of any project before its establishment shall be abode to prepare a report regarding the estimation of environmental impact including as the following:
   A. The estimation of negative and positive impact of the project on the environment and impact of surrounding environment on it;
   B. The proposed means to avoid and to treat the causes of the pollution to be abode by Environmental regulations and directives;
   C. Emergency pollution cases and probability and the precautions should be taken to prevent its occurrence;
   D. The possible alternatives to use technology less harmful for the environment and rationalizing the resources usage;
   E. Reduction the waste and recycle or reuse it as much as possible; and,
   F. Evaluation of environmental feasibility for the project and evaluation the cost of pollution compare with the production
II. Economical and technical feasibility study for any project shall contain the report stipulated in the provision (first) of this article.

Projects are to be divided into three (3) categories as follows[21]:

Environment Polluting Activities Category (A): They are the intensive environment polluting activities, including huge agricultural or industrial projects that have several impacts on environment quality on large areas, so they have to be far away from the principal designs and their expansion of cities, districts, subdistricts and villages nominated for development according to the plan of rural housing with the condition of providing all treatment providing enough environmental protection.
Environment Polluting Activities Category (B): They are the activities polluting with less degrees than category (A), including industrial or agricultural and other resources producing site pollution that can be controlled, so they can be established inside the boundaries of principal designs and within the block allocated for them, provided that treatment units are to be available according to instructions and regulations; and in case it is not possible to control all pollutions aspects (bad smells and the like), the site will be set outside the boundaries of principal designs according to the site restrictions of such type of activities that are mentioned in details within the regulations.
Environment Polluting Activities Category (C): They are other human activities causing minor pollution that can be treated, such as industrial factories that are not causing significant pollution, small agricultural projects, residence compounds, hotels and hospitals that produce pollutions of mainly organic content and can be easily treated via treatment units, so they can be established within the boundaries of the principal designs with no restrictions as well as outside them, according to the central regulations, that farm owners are allowed to establish un-polluting industries inside their farms.

Although the present law (No. 27 of 2009) uses the following table, the principle categorization of projects is the same as above. The projects categorized as Class A and B need EIA reports (Table 5-4-1).

[21] Environmental Regulations for Industrial, Agricultural and Service Projects (No.14 of 1990). This law is formulated to pursue the Law of Protecting and Improving the Environment (No. 76 of 1986).

Table 5-4-1 EIA classes

Class A	Class B
• Chemical , petrochemical and petroleum industries • Synthetic fiber industry • Protein plants • Pharmaceutical industries • Tannery plants • Cement plants • Gypsum plants • Bricks plants • Asbestos products plants • Mines • Glass and ceramic industries • Thermal power stations • Hazardous waste dumping sites • Asphalt plants • Iron , steel and aluminum industries • Waste water treatment plants • Rocks grinding plants	• Food industries • Slaughtering houses • Gas power stations • Solid waste landfills • Fish breeding lakes • Textile industries • Chemical industries ,low production capacity • Construction products industries • Metal Melting plants • Electronic and electrical industries. • Fertilizer storage building • Pesticides storage building • Soap industries • Ice production plant • Sand and rocks serving sites • Tobacco industries • Reuse waste oil plants • Electro power transfer station

Key Stages of the process of EIA (Figure 5-4-2) are described as follows:

Consultation and Scoping: They are the activities of identifying significant potential environmental impacts and deciding the focus of the EIA report and identifying the stakeholders. Consultation with MOEN Provincial office shall be held by the developer. The Provincial office may advise the developer on the scope of the EIA report and how to carry out farther consultation. Consultation should be held with the concerned public, stakeholders, municipalities and concerned ministries. Comments given during the consultation shall be taken into account and presented in the EIA report.

Preparing an EIA Report: The developer performs environmental studies to collect and prepare an EIA report, and the report shall cover the different phases of the realization of the project such as pre-construction, construction, operation and decommissioning or closure. The developer shall submit the EIA report and the agreements from the concerned ministries to the Provincial office and then to the Ministry of Environment in Baghdad (EIA Department).

Review of the EIA: MOEN in Baghdad reviews EIA reports. MOEN may require the developer to revise the project design or to conduct farther EIA studies and/or submit additional information. Any such requests from MOEN must be submitted by means of an official letter through the Provincial Office within 45 days from receiving the EIA report. The Provincial Office forward the requests to the developer.

Environmental Compliance Certificate: MOEN gives the approval and issues the Environmental Compliance Certificate (license) for Class A and B Projects, in which the conditions that need to be fulfilled are stated. The Provincial Office issues the Environmental Compliance Certificate for Class C Project. Within the Environmental Compliance Certificate the developer can apply for a permit from the relevant ministries. No construction works or activities can be implemented before a permit is issued.

Monitoring: Monitoring is important to ensure that the terms and condition stated in the Environmental Compliance Certification are fulfilled. Monitoring action shall be described in the Environmental Management Plan (EMP) which is part of EIA report.

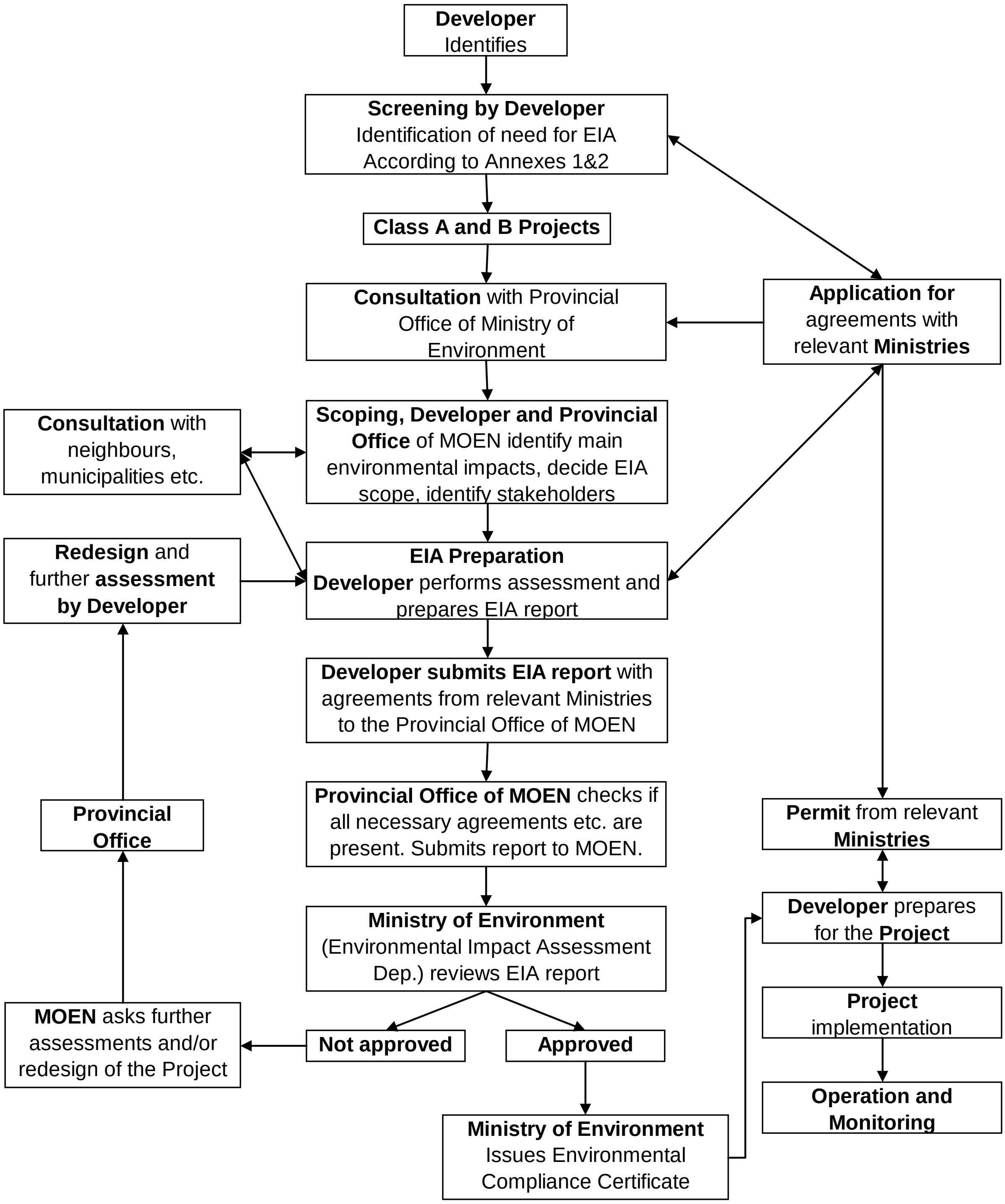


Figure 5-4-2 EIA process[22]

[22] From the presentation material by MOEN at United Nations Economic Commission for Europe MOS 3 in November 2010.

(3) Legislation on environmental issues

(a) Laws in Iraq

In Iraq, there are various environmental laws that are mainly concerned with the assessment, control, and monitoring of environmental pollution. Table 5-4-2 and 5-4-3 show the laws related to environmental issues.

Table 5-4-2 Existing Iraqi Environment-related Laws

Reference	Title	Current status
2009 – Law No. 30 (formerly 1955 – Law No. 75)	Forest Law	Updated 2009, Ongoing
1965 – Law No. 64	Cities land use	Ongoing
1965 – Law No. 106	Rangelands and their Protection	Ongoing
1966 – Law No. 21	Noise prevention	Ongoing
1967 – Law No. 25	System of rivers and other water resources protection from pollution (includes 45 pollutants)	Updated 2001, Ongoing
1976 – Law No. 48	Fishing, exploitation and protection of living aquatic species.	Ongoing
2010 – Law No. 17 (formerly 1979 – LAW No. 21)	Law on the protection of wild animals and birds	Updated in 2010, Ongoing
1980 – Law No. 99	Protection from Ionizing radiation	Ongoing
1981 – Law No. 89	Public health (drinking water provision, sanitation and environmental monitoring)	Ongoing
1997 – Law No. 3 (formerly 1986 LAW No. 79)	Protection and improvement of environment	Updated 2008, Ongoing
1994 – Law No.24	Planning Body	Ongoing
1995 – Law No.12	Maintenance of networks of irrigation and drainage	Ongoing
2001 – Law No. 2	Water systems protection	Ongoing
2009 – Law No. 29 (1986-Regulation No. 67)	Updates Regulation No. 67, Regulate the regions for collecting debris (landfills).	Ongoing
OTHERS		
1961 – Regulation No. 33	Lease of beaches, islands and Miri surf lands on which pastures or liquorice are naturally grown	Ongoing
1981 – Regulation No. 13	Agricultural Research and Water Resources Centre	Updated 2008, Ongoing
2009 – Regulation No. 17 (formerly 1985-Resolution No. 995)	Establishment of aquaculture operations	Updated 2009, Ongoing
1990 – Order No. Unknown	Environmental criteria for agricultural, industrial and public service projects	Ongoing
1991 – Decision No. 1 (EPB)	Cutting of trees	Ongoing
1992 – Instructions No. 11	Prohibition of plant importation into Iraq	Ongoing

Table 5-4-3 Newly Approved and or Updated Iraqi Environment-related Laws[23]

Reference	Title	Current status
2010 – Law No.1	Consumer protection law	Approved
2010 – Law No.11	Protection of the Iraqi production	Approved
2009 – Law No. 3	Joining in Basil convention for controlling the danger hazards.	Approved
2009 – Law No.7	Iraq joining the convention of Desertification	Approved
2009 – Law No. 27	Iraqi Environmental protection and improvement law	Approved
2009 – Law No.28	Agricultural Loans to support the Iraqi farmers	Approved
2009 – Law No. 30	Law of Forests and nurseries	Approved
2008 – Law No. 7	Iraq joining the Climate Change Convention and Kyoto protocol	Approved
2008 – Law No.12	Iraq joining Convention Concerning the Protection of the World Cultural and Natural Heritage	Approved
2008 – Law No. 37 (formerly 2003 – CPA ORDER 44)	Ministry of Environment Law - Establishment of the Ministry (instead of the former Council of Protection and Improvement of Environment)	Updated in 2008
2007 – Law No. 6	Iraq joining the Arabian memorandum of understanding in cooperation in marine transportation	Approved
2007 – Law No. 7	Iraq joining Convention on Wetlands of International Importance Especially as Waterfowl Habitats	Approved
2007 – Law No. 22	Iraq joining the international agreement for Olive Oil	Approved
2007 – Law No. 42	Iraq joining Vienna convention and Montreal protocol to protect the Ozone layer	Approved
2007 – Law No. 48	Iraq joining the regional commission for Fish traps	Approved
2007	Investment law for Oil refineries	Approved but not published
2008 – Law No. 31	Iraq joining the Convention on Biological Diversity	Approved
2010 – Order No. 74	Prohibition of plant importation into Iraq – To identify the Ministry of Environment and Ministry of Agriculture as having sole authority over plant importation, to state that all plants are prohibited for importation, and to support Instructions No. 11.	Ongoing

There are other important laws promoted by the Ministry of Environment and currently under approval, such as: the Draft Regulation on Nature Protected Areas and the Draft Law for Regulating Hunting Activity[24].

(b) International and regional conventions

Iraq is members of various international and regional conventions on environmental issues. Table 5-4-4 shows the status of the important conventions.

[23] Iraqi Fourth National Report to the Convention on Biological Diversity (2010).
[24] Iraqi Fourth National Report to the Convention on Biological Diversity (2010).

Table 5-4-4 International and Regional Conventions[25]

Title	Current status
Atmosphere	
Vienna Convention for the Protection of Ozone Layer	2008
United Nations Framework Convention on Climate Change	2009
Waste Management	
Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal	2011
Natural Conservation	
Convention on Biological Diversity	2009
Convention on Wetlands of International Importance Especially as Waterfowl Habitats	2008
Convention Concerning the Protection of the World Cultural and Natural Heritage	1974
United Nations Convention to Combat Desertification	2010
Regional convention	
Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution	1979

(4) Standards

(a) National standards

Standards related to the Project are shown in Table 5-4-5, 5-4-6, 5-4-7 and Table 5-4-8.

Table 5-4-5 Iraqi national standards for ambient air quality[26]

No.	Pollutant	Period of measurement	Limitation value
1	SO_2	1 hr	0.1 ppm
		24 hr	0.04 ppm
		1 yr	0.018 ppm
2	CO	1 hr	35 ppm
		8 hr	10 ppm
3	NO_2	1 hr	0.04 ppm
		24 hr	0.05 ppm
4	O_3	1 hr	0.06 ppm
5	PM_{10}	24 hr	150 μg/m^3
6	$PM_{2.5}$	1 hr	15 μg/m^3
		24 hr	65 μg/m^3

[25] The information of the conventions and agreement is obtained from each convention's website on 20 September 2011.

[26] Ministry of Environment (in aprocess of approval, from Environmental Impact Assessment Study for Akkas Gaseous Power Plant Project, 2009)

No.	Pollutant	Period of measurement	Limitation value
7	Total suspended particulates (TSP)	1 hr	150 μg/m^3
		24 hr	350 μg/m^3
8	Dust falling	30 day	Residential area: 10 T/km^2/month
			Industrial area: 20 T/km^2/month
9	HC	3 hr	160 μg/m^3
10	Pb	24 hr	2 μg/m^3
		3 month	1.5 μg/m^3
		1 yr	1 μg/m^3
11	Gasoline	1 yr	0.003 mg/m^3
12	Dioxane	1 yr	0.6 pico g/m^3

Table 5-4-6 Iraqi national standards for emission air quality (maximum limit from fixed sources)[27]

No.	Name of air emission	Symbol	Source of emission	Max. limit of emission mg/Nm^3
1	Smoke and visible contaminant emission		Combustion or burning source	250
			Other sources	0.0
2	Opacity		All sources	20.0%
3	Carbon Monoxide	Co	All sources	500
4	Oxides of nitrogen (measured as NO_2)	NO_x	Combustion or burning source	70 - 500
			Materials production	1000
5	Sulfur dioxide	SO_2	Combustion or burning source	500
			Materials production	2000
			Other sources	1000
6	Tri- sulfur oxide (include fog of sulfuric acid, measured as SO_3)	SO_3	Materials production	150
			Other sources	50
7	Total Suspended Particulates	TSP	Combustion or burning source	250
			Cement production	150
			Cement production	100
			Other sources	150
8	Ammonia and ammonium compounds		Materials production	50
			Other sources	10
9	Benzene	C_2H_6	All sources	5
10	Iron	Fe	Iron and steel factory	100
11	Lead and lead complex	Pb	All sources	5
12	Antimony and Antimony complex	Sb	Materials production	5
			Other sources	1
13	Arsine and Arsine complex	As	All sources	1
14	Cadmium and Cadmium complex	Cd	All sources	1

27 Ministry of Environment (2011, in process of approval, from information of MOE)

No.	Name of air emission	Symbol	Source of emission	Max. limit of emission mg/Nm^3
15	Mercury and Mercury complex	Hg	All sources	0.5
16	Chromium and Chromium complex	Cr	All sources	5
17	Nickel and Nickel complex	Ni	All sources	1
18	Copper	Cu	All sources	5
19	Hydrogen sulfide	H_2S	Materials Production	10
			Other sources	5
20	Chloride	Cl^-	Chloride Production	200
			Other sources	20
21	Hydrogen fluoride	HF	All sources	2
22	Hydrogen chloride	HCl	Chloride production	200
			Other sources	10
23	Silicon fluoride	SiF_4	All sources	10
24	Fluoride (include HF, Sif_4)	F^-	Aluminum smelter	20
			Other sources	50
25	Formaldehyde	CH_2O	Materials production	20
			Other sources	2
26	Carbon	C	Materials production	250
			Other sources	50
27	Volatile Organic Compounds	VOC	All sources	20
28	Dioxin and Furans		All sources	1 (ng TEQ/m^3)

Notes

1. Combustion or burning source means burners and boilers of oil and petro-chemical industries or manufacture and power station. Materials production mean structural industries, chemical industries and dyes industries.
2. The concentration of any material in the second column, when it measured from any sources in the third column, before mixing with air, smoke, and other gases, the maximum limit in the fourth column.
3. The limit of smoke and visible emission, must not used with water vapor, and not for starting or shut downing burning.
4. The limit of NO_x for turbine units, working by using gas, and installing before this law is 125 mg/Nm^3.
5. Measuring TSP emitted from burning source measured at 12% of CO_2 as a reference.
6. Standard cubic meter is cubic meter of gas at 25 °C and 760 mm/hg.
7. Overall concentration of heavy metals (Pb, Cd, Cr, Ni, Hg, Cu, As, Sb) in any measurement must not exceed 5 mg/Nm^3.
8. The limit of VOC is for the unburned hydro-carbons .
9. The limits for all contaminants except Dioxin and Furans are measured for 24 hours. In measuring the concentrations of any material in the second column, the method used by the American Environmental Agency as reference method, or any equivalent standard method used.

TEQ : Toxic Equivalent

Table 5-4-7 Iraqi national water quality standards[28]

	Parameter (unit: mg/l)	Water Source			
		A-1 rivers	A-2 streams	A-3 lakes	A-4 springs
1	Color (-)	Normal	Normal	Normal	Normal
2	Temperature (deg C)	-	-	-	-
3	Suspended Solid	-	-	-	-
4	pH (-)	6.5-8.5	6.5-8.5	6.5-8.5	-
5	Dissolved Oxygen	>5	>5	>5	-
6	BOD	<3	<3	<3	-
7	COD (CrO method)	-	-	-	-
8	Cyanide CN^-	0.02	0.02	0.02	0.02
9	Fluoride F^-	0.2*	0.2*	0.2*	0.2*
10	Free Chlorine	Trace	Trace	Trace	Trace
11	Chloride Cl^-	200*	200*	200*	200*
12	Phenol	0.005	0.005	0.005	0.005
13	Sulphate SO_4^{2-}	200*	200*	200*	200*
14	Nitrate NO_3	15	15	15	15
15	Phosphate PO_4	0.4	0.4	0.4	0.4
16	Ammonium NH_4^+	1	1	1	1
17	DDT	nil	nil	nil	nil
18	Lead	0.05	0.05	0.05	0.05
19	Arsenic	0.05	0.05	0.05	0.05
20	Copper	0.05	0.05	0.05	0.05
21	Nickel	0.1	0.1	0.1	0.1
22	Selenium	0.01	0.01	0.01	0.01
23	Mercury	0.001	0.001	0.001	0.001
24	Cadmium	0.005	0.005	0.005	0.005
25	Zinc	0.5	0.5	0.5	0.5
26	Chromium	0.05	0.05	0.05	0.05
27	Aluminum	0.1	0.1	0.1	-
28	Barium	1.0	1.0	1.0	1.0
29	Boron	1.0	1.0	1.0	1.0
30	Cobalt	0.05	0.05	0.05	0.05
31	Iron	0.3	0.3	0.3	0.5
32	Manganese	0.1	0.1	0.1	0.1
33	Silver	0.01	0.01	0.01	0.01

Water Source Category:
A-1 Rivers, Branches
A-2 Streams, aqua ducts, water courses and their original and secondary branches
A-3 Lakes, Basins and other water bodies
A-4 Springs, wells and underground water
Notes:
*) Quality standard are to be set in the listed value or more according to what is existed naturally in the source.

[28] The New Limits of the Regulation of the Protection of Rivers and Public Waters for a Year 1967, Ministry of Health, Directorate General of Human Environment (from Baiji Refinery Upgrading Project – Preliminary Environmental and Social Impact Assessment, 2010)

Table 5-4-8 Iraqi national wastewater discharge limit standards[29]

No.	Parameter (unit : mg/l)	Wastewater discharged to			
		B-1 any water source	B-2 public sewers	B-3 drainage	B-4 marshes
1	Color (-)	-	-		
2*	Temperature (deg C)	< 35	45		
3*	Suspended Solid	50	750		
4*	pH (-)	6-9.5	6-9.5		
5	Dissolved Oxygen	-	-		
6*	BOD	<40	1000		
7*	COD (CrO method)	<100	-		
8*	Cyanide CN^-	0.05	0.5		
9	Fluoride F^-	5	10		
10*	Free Chlorine	Trace	100		
11	Chloride Cl^-	*a) <1% *b)< 600 mg/l *c)			
12*	Phenol	0.01-0.05	5-10		
13	Sulphate SO_4^{2-}	**a) <1% **b)<400 mg/l **c)<200 mg/l	300		
14	Nitrate NO_3	50	-		
15*	Phosphate PO_4	3	-		
16	Ammonium NH_4^+	-	-		
17	DDT	Nil	-		
18*	Lead	0.1	0.1		
19	Arsenic	0.05	0.05		
20*	Copper	0.2	-		
21*	Nickel	0.2	0.1		
22	Selenium	0.05	-		
23*	Mercury	0.005	0.001		
24*	Cadmium	0.01	0.1		
25	Zinc	2.0	0.1		
26*	Chromium	0.1	0.1		
27	Aluminum	5.0	20		
28	Barium	4.0	0.1		
29	Boron	1.0	1.0		
30	Cobalt	0.5	0.5		
31*	Iron	2.0	15.0		
32	Manganese	0.5	-		
33	Silver	0.05	0.1		
34*	Total Hydrocarbons and its compounds	Note ***	Note ***	Note ***	Note ***
35*	Sulphide S^{2-}	-	3.0		
36	Ammonia	-	10.0		

29 The New Limits of the Regulation of the Protection of Rivers and Public Waters for a Year 1967, Ministry of Health, Directorate General of Human Environment (from Baiji Refinery Upgrading Project – Preliminary Environmental and Social Impact Assessment, 2010)

No.	Parameter (unit : mg/l)	Wastewater discharged to			
		B-1 any water source	B-2 public sewers	B-3 drainage	B-4 marshes
37	Ammonia gas	-	6.0		
38	Sulphur Dioxide	-	7.0		
39	Petroleum Alcohol	-	Not permissible		
40	Calcium Carbonate	-	Not permissible		
41	Organic Solvent	-	Not permissible		
42*	Benzene	-	0.5		
43	Chlorobenzene	-	0.1		
44	TNT	-	0.5		
45	Bromine	-	1-3		

Wastewater: Category:

B-1 Waste water discharged to any water source

B-2 Waste water discharged to public sewers – Special conditions should be defined taking in consideration the limits mentioned in item B-1.

B-3 Waste water discharged to drainage – Special conditions should be defined taking in consideration the limits mentioned in item B-1.

B-4 Waste water discharged to marshes – Special conditions should be defined taking in consideration the limits mentioned in item B-1.

Notes:

* Item 11- Chloride Cl^-

**Item 13- Sulphate SO_4^{2-}

*a) When the ratio of the amount of the discharged water to the source water is (1:1000) or less

*b) When the ratio of the amount of the discharged water to the source water is more than (1:1000)

*c) When the ratio of the amount of the discharged water to the source water isles than 200 mg/l, then each case should be studied by the responsible authority for executing this regulation.

***Item 34- Total Hydrocarbons and its compounds

It is allowed to discharge to the water sources A1 & A2 according to the concentration limits that are shown below.

It is not allowed to discharge any hydrocarbons to water sources A3 & A4.

1) 10 mg/l

a) When the ratio of the amount of the discharged water to the source water is (1:1000) or less

b) The river should be flowing.

2) 5 mg/l

a) When the ratio of the amount of the discharged water to the source water is (1:500) or less

b) The river should be flowing.

3) 3 mg/l

a) When the ratio of the amount of the discharged water to the source water is (1:300) or less

b) The river should be flowing.

(b) International Standards

Since some of Iraqi legislations and standards have not been prepared, the following international standards are applied to the Project (Table 5-4-9, 5-4-10, 5-4-11, 5-4-12 and 5-4-13).

Table 5-4-9 Ambient air quality[30]

Parameter		Guideline Value (Unit: μg/m^3)
SO_2	Maximum 24-hour average	Interim target 1: 125 Interim target 2: 50 Guideline: 20
	10 minutes average	500
NO_2	1-year average	40
	1 hour average	200
PM_{10}	1-year average	Interim target 1: 70 Interim target 2: 50 Interim target 3: 30 Guideline: 20
	24-hour average	Interim target 1: 150 Interim target 2: 100 Interim target 3: 75 Guideline: 50
$PM_{2.5}$	1-year average	Interim target 1: 35 Interim target 2: 25 Interim target 3: 15 Guideline: 10
	24-hour average	Interim target 1: 75 Interim target 2: 50 Interim target: 37.5 Guideline: 25
Ozone	8-hour daily maximum	Interim target: 160 Guideline: 100

Notes:
- World Health Organization (WHO). Air Quality Guidelines Global Update, 2005. PM 24-hour value is the 99th percentile.
- Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines

[30] International Finance Corporation (IFC): Environmental, Health, and Safety General Guidelines (2007)

Table 5-4-10 Air emissions for thermal plant[31]

Pollutant	Emissions Guidelines (Unit: mg/Nm^3)	
	Natural gas (all turbine types of Unit > 50MWh)	Fuel other than natural gas (Unit > 50MWh)
NOx	50 (25 ppm)	152 (74 ppm)
SOx	N/A	NDA: Use of 1% or less S fuel DA: Use of 0.5% or less S fuel
Particle Matter	N/A	NDA: 50 DA: 30
Dry gas, excess O_2 content (%)	15%	15%

Notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm3 is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm^3.

[31] IFC: Environmental, Health, and Safety Guidelines THERMAL POWER PLANTS (2008)

Table 5-4-11 Effluent guidelines for thermal plant[32]

Pollutant	mg/L, except pH and temperature
pH	6 – 9
TSS	50
Oil & Grease	10
Total residual chlorine	0.2
Chromium – Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temperature increase by thermal discharge from cooling system	▪ Site specific requirement to be established by the Environmental Assessment (EA). ▪ Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.
Note: Applicability of heavy metals should be determined in the EA. Guideline limits in the Table are from various references of effluent performance by thermal power plants.	

Table 5-4-12 Noise level guidelines[33]

Receptor	One hour L_{Aeq} (dBA)	
	Daytime 07:00 – 22:00	Nighttime 22:00 – 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

dBA : decibel A

32 IFC: Environmental, Health, and Safety Guidelines THERMAL POWER PLANTS (2008)
33 International Finance Corporation (IFC): Environmental, Health, and Safety General Guidelines (2007)

Table 5-4-13 British standard of the allowable vibration[34]

Building classification	Maximum acceptable continuous vibration value (PPV) for day and night time
Residential in general good repair	5
Residential where preliminary survey reveals significant defect	2.5
Industrial / commercial – light and flexible structure	15
Industrial / commercial – heavy and stiff structure	15

PPV : Peak Particle Velocity

[34] British standard, BS 5228: part 4 (1992)

5.4.3 General Description of the Environments

(1) Physical and natural environments

(a) Geographical features and general vegetation status[35]

Iraq is bordered by Iran, Kuwait, Saudi Arabia, Jordan, Syria and Turkey. Its vegetation is roughly described as follows: about the 80 % of the country is desert, about 15 % is steppe, and about 5 % is forest and high mountain scrub. The country can be divided into four main biogeographical regions (Figure 5-4-3). The vegetations and landscapes are closely related each other.

- Lower Mesopotamia

  This region is the flat flood plain of the Tigris and Euphrates rivers. In the triangle between Amara, Nasiryah and Basra, there are extensive areas of permanent or seasonal shallow lakes, including the Central Marsh and Al Hawizeh Marsh.

- Desert Plateau

  This is a vast area of desert south-west of the Euphrates, rising to an elevation of about 1,000 m close to the Syrian border in the west.

- Upper Plains and Foothills

  This region is separated from Lower Mesopotamia by a low range of hills, Jabal Hamrin (up to about 200 m) which extends across the country in a north-westerly direction from Mansuriya (100 km north-east of Baghdad). It is dominated by steppic plains and the, lower mountain slopes. Altitude varies from 200 to 500 m, and rainfall increases towards the northern mountains.

- Mountains

  The region is bounded by the north and north-eastern border of Iraq with rolling plains intersected by many, deep, well-watered valleys and gorges. Altitude varies from 500 m to over 3,500 m. There is only about 4 % of natural forest left in Iraq, nearly all of them in this region, and mostly over-exploited and overgrazed.

[35] Important Bird Areas in the Middle East (BirdLife International, 1994)

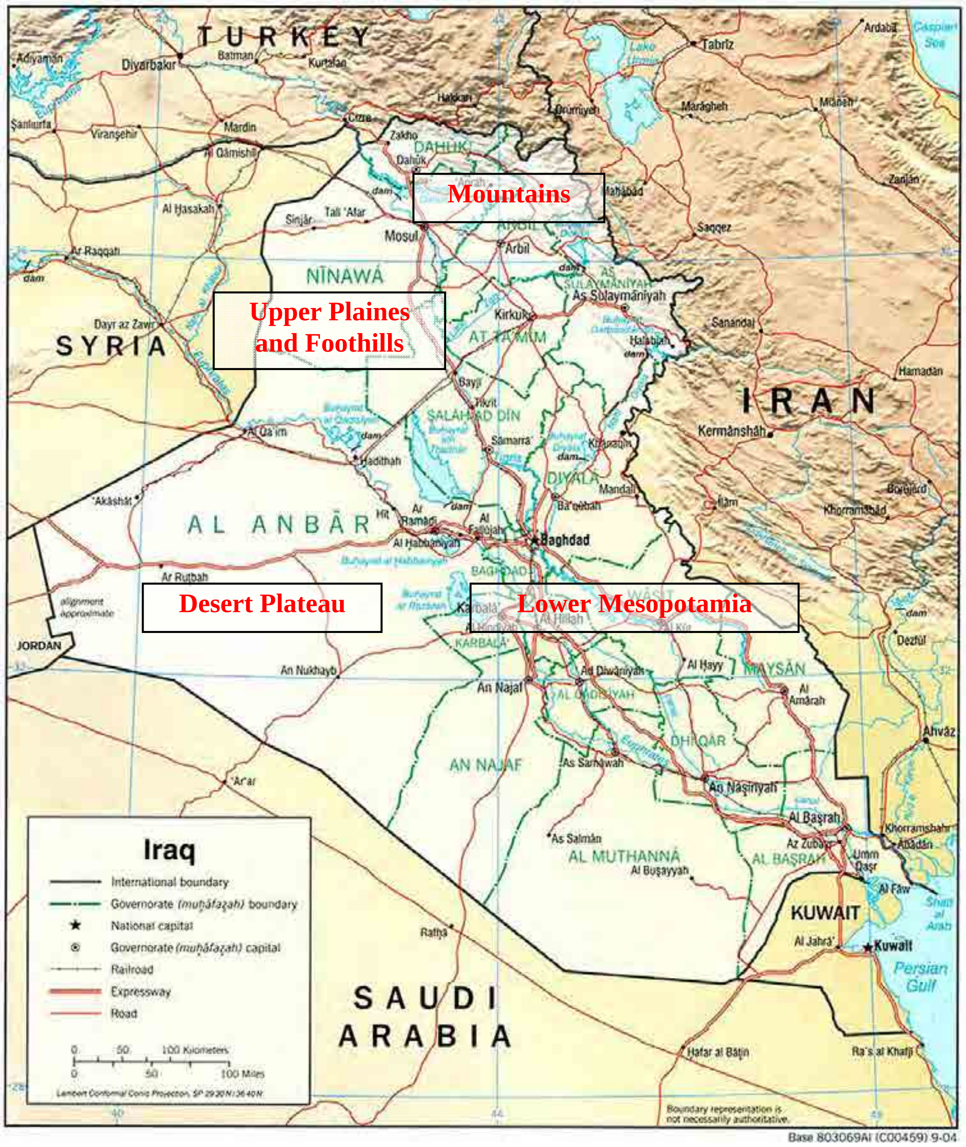


Figure 5-4-3 Biogeographical Regions in Iraq[36]

(b) Climate[37]

Iraq lies within the moderate northern regional system similar to that of Mediterranean where rainfall occurs almost in spring, autumn and winter, and does not in summer. The climate can be categorized into the following three groups:

Mediterranean climate: it covers the mountainous region in the north-eastern part of the country which is characterized by cool winter with snow falls at the top of mountains. Its annual rainfall ranges between 400 – 1,000 mm. Its summer is moderate and the temperature does not exceed 35° C in most of its area.

---

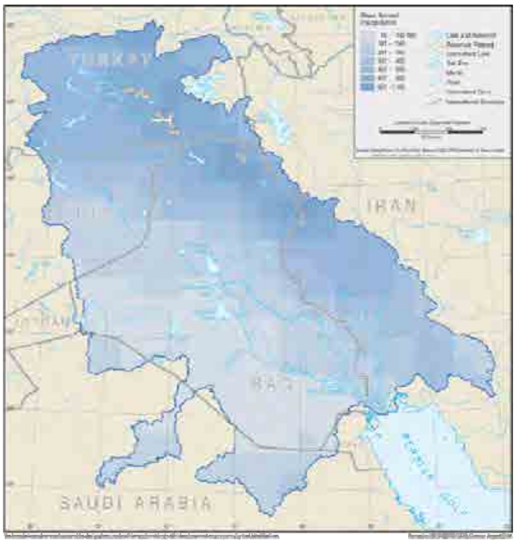
[36] The base map is from "Perry-Castañeda Library (University of Texas, USA)".

[37] Annual Abstract of Statistics 2008-2009 (Central Organization for Statistics and Information Technology, Iraq).

Steppes climate: It is a transitional climate between the mountainous region in the north and the hot desert in the south. This climate prevails in the terrain area with annual rainfall ranging between 200 - 400 mm.

Hot desert climate: It prevails in the sedimentary plain and western plateau. Annual rainfall ranges between 50 - 200 mm. The maximum temperature reaches at 45 - 50 ° C in summer. In winter, warm weather prevails and the temperature remains above frost point temperature and does not fail below it except for few nights.

Figure 5-4-4 shows that mean annual precipitation (2000-08) and Figure 5-4-5 shows that mean annual temperature (2000-08) in Tigris and Euphrates river basins[38].



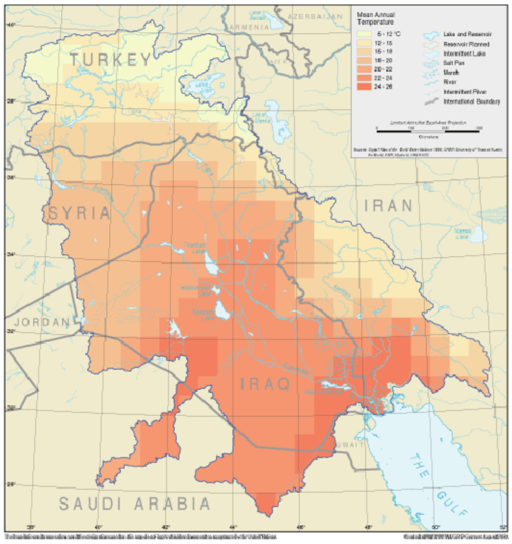


Figure 5-4-4 (left) Tigris and Euphrates: Mean annual precipitation (2000-08)

Figure 5-4-5 (right) Tigris and Euphrates: Mean annual temperature (2000-08)

(c) Terrestrial and freshwater ecosystems

The Iraq contains portions of the following five terrestrial eco-regions identified by WWF[39]: Tigris-Euphrates alluvial salt marsh; Arabian Desert and East Sahero-Arabian Xeric Shrublands; Mesopotamian Shrub Desert; Middle East Steppe; and Zagros Mountains Forest Steppe. The Project area is mainly within or close to Tigris-Euphrates alluvial salt marsh eco-region[40]. The eco-region is part of a former cradle of civilization (Mesopotamia), and it is surrounded by a vast region of desert and xeric shrubland. This complex of shallow freshwater lakes, swamps, marshes, and seasonally inundated plains is among the most important wintering areas for migratory birds in Eurasia[41].

---

[38] United Nations Environment Programme DEWA/GRID-Geneva: http://www.grid.unep.ch/product/map/index.php

[39] Iraqi Fourth National Report to the Convention on Biological Diversity (2010).

[40] This ecoregion is closely associated with biogeographical region "Lower Mesopotamia" in the "Geographical features and general vegetation status". Some areas belong to other ecoregions but their areas are much smaller than the ones described in the text.

[41] It is extracted from the description from the following site. http://www.worldwildlife.org/wildworld/profiles/terrestrial/pa/pa0906_full.html

"Lower Tigris & Euphrates" freshwater eco-region is also identified by WWF/TNC[42], and it overlaps the area of "Tigris-Euphrates alluvial salt marsh". The importance of the freshwater eco-region is the same as the one of the terrestrial eco-region.

In this region, Mesopotamian Marshlands forms the core area of the eco-region, which mainly consists of the Central, Hammar and Hawizeh Marshes. MOEN describes that the lower part of the marshland has a strong influence of the tidal intrusion, and several marine fish species which can also live in brackish and fresh water are found in the marshlands (the lower basin) such as the bull shark *Carcharhinus leucas*, which has been seen as far north as Baghdad; Hilsa shad *Tenualosa ilisha*, which enters the rivers and marshes of Iraq for spawning; and Yellowfin seabream *Acanthopagrus latus*[43].

Although the statues of 90 % of the wetland was known as deteriorated in 2001, it has been being restored through international support by UNEP and other countries such as Japan and Italy[44]. UNEP and other donors are working closely with MOEN, Ministry of Water Resources and Ministry of Municipalities and Public Works.

(d) Key Biodiversity Areas, Important Bird Areas

International and national efforts have been paid for identification of Key Biodiversity Areas (KBAs) in each country for effective conservation of its biodiversity[45]. This exercise is still in progress based on the information of "Important Bird Areas (IBAs: BirdLife International)". The list of 42 of IBAs is shown in Attachment - 11.

(e) Endangered species

IUCN has been updating the data on internationally endangered species of fauna and flora, and the list of them in Iraq is shown in Attachment - 12.

(f) Natural Protected areas

In Iraq, MOEN is in charge of managing the natural protected area system and there are two main protected areas in southern Iraq: proposed Mesopotamia Marshlands National Park and Hawizeh Ramsar Wetland indicated in Figure. 5-4-6.

The MOEN is working with Nature Iraq (NI) and the New Eden Group to designate Iraq's first National Park in the Mesopotamia Marshlands. A draft management plan exists for this park and the site information is currently being updated by NI/New Eden Group. In February 2008, Iraq designated the Hawizeh Marsh located in southern Iraq as a Ramsar site. A draft management plan was prepared and is under review by the National Ramsar Committee. To date no protected areas management actions have taken place in Hawizeh and no national legislation has been passed to strengthen protection of this area[46].

---

[42] Freshwater Ecoregion of the World: http://www.feow.org/index.php

[43] Iraqi Fourth National Report to the Convention on Biological Diversity (2010).

[44] Support for Environmental Management of the Iraqi Marshlands 2004-2009 (UNEP, 2009)

[45] KBAs are sites of global significance for biodiversity conservation, identified using globally standard criteria and threshold, based on occurrence of species requiring safeguards at the site scale (Identification and Gap Analysis of Key Biodiversity Areas: IUCN, 2007). In Iraq, Nature Iraq, a nature conservation NGO, has been working on the identification of KBAs.

[46] Iraqi Fourth National Report to the Convention on Biological Diversity (2010).

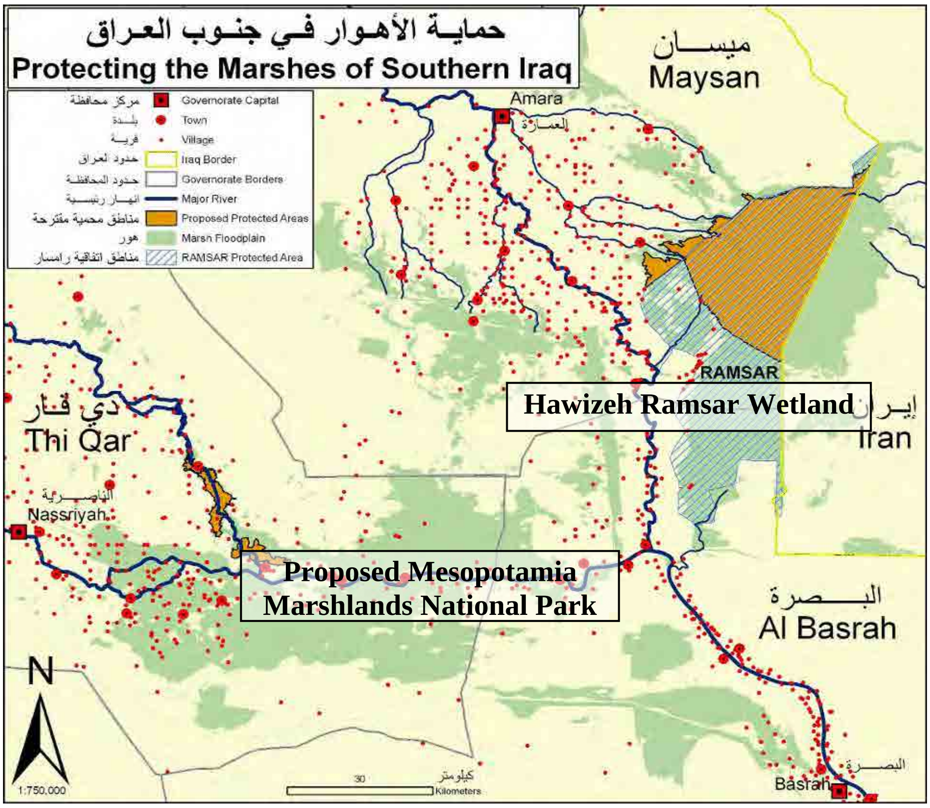


Figure 5-4-6　Natural Protected Areas in the Southern Iraq[47]

[47] University of Victoria Libraries: https://dspace.library.uvic.ca:8443/handle/1828/2560

(g) Seismic status of the southern part of Iraq

The southern part of Iraq is located at the south-west of Zagros Fold Belt[48] (Figure 5-4-7) and is identified as a "stable platform". It means that the area is not subject to a large earthquake or under any other unstable seismic activities as shown in Figure 5-4-8.

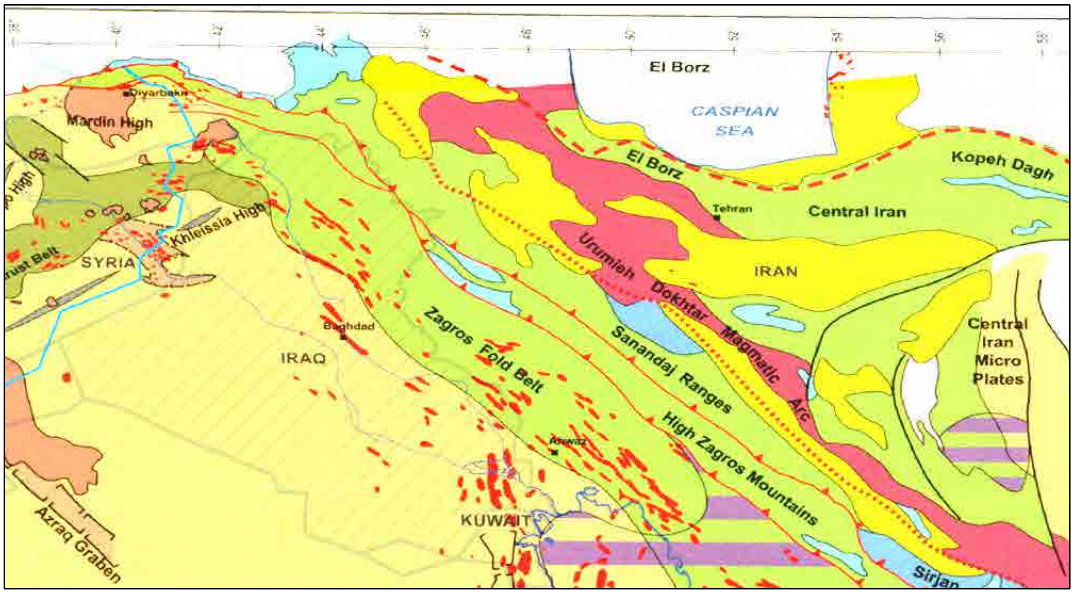


Figure 5-4-7 Wide Area Geological Map around Iraq

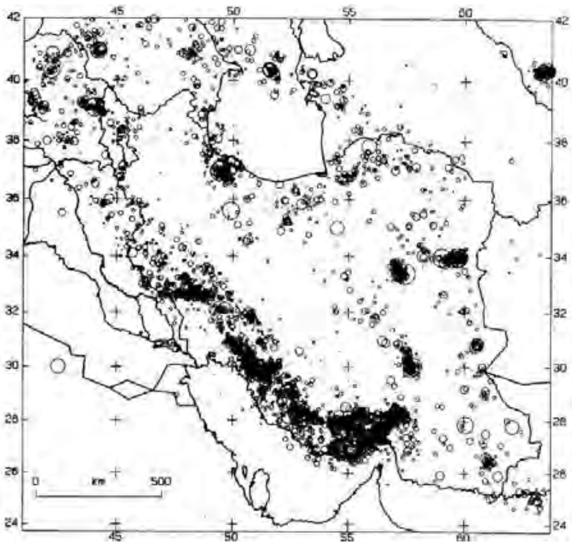


Figure 5-4-8 Recent seismicity of Iran and its Surrounding Areas[49]

[48] Part of "Technical element of Arabian Plate and Iran" from "Konert, G., A.M. Afifi, S.A. Al-Hajri, K. de Groot, A.A. Al Naim, and H.J.Droste, Paleozoic stratigraphy and hydrocarbon habitat of the Arabian Plate, *in* Petroleum Provinces of the Twenty First Century: AAPG Memoir 74, p. 483-515". Red dots in the map show oil and gas fields.

[49] http://www.seismo.ethz.ch/static/GSHAP/

(h) Pollution[50]

Air pollution: The various sources have polluted the air in most Iraqi cities and suburbs, with a tendency toward increasing pollution levels as city size and polluting activities increase. These problems are exacerbated by poor environmental legislative deterrents for offenders and weak monitoring and surveillance systems. The leading types of air pollution are lead, floating particles, concentration of carbon dioxide, sulfur, and falling dust. Some pollution concentrations are not measured because of lack of measuring instruments or, to the extent they exist, equipment malfunction. There is also a lack of some analysis equipment.

Water pollution: The main types of water pollutants in Iraq include: liquid industrial pollutants, organic pollutants, effluents from hospitals, sewage water, car washes, lubricants, oil pollutants, and drainage water. Weak environmental oversight of industrial activities has made matters worse, as has noncompliance with environmental requirements.

Soil pollution: Iraq is facing deterioration in the quality of its soil elements and degradation of their physical, chemical, and biological properties. This has caused productive land to become barren (desertification) or to become less productive. The causes are various: human activities such as clearing of trees for agricultural, fueling, or construction purposes; high soil salinity; an unscientific approach to the use of fertilizers and agricultural pesticides; over-irrigation; the removal of vegetation covers; unsustainable management of solid waste.

Solid waste management: There are no specific data on solid waste management in the National Development Plan, but the Iraq Partners Forum[51] indicates that solid and chemical wastes are poorly managed in the country.

(2) Social Environment

(a) Population

The basic statistics of the population of Iraq are shown in Table 5-4-14[52].

Table 5-4-14 Basic Statistics of Population of Iraq

Item	Year	Figure
Surface area (km^2)	2008-2009	435,052
Total population (000)	2009	32,105
Population (male; 000)	2009	16,163
Population (female; 000)	2009	15,942
Population density ($/km^2$)	2009	73

(b) Local administrative bodies

The constitution of 2005 allots wide powers to the federal government but explicitly stipulates shared powers in customs, health, education, and environmental and natural resource policy and relegates all non-stipulated authority to the sub-national jurisdictions. Governorates are subdivided into districts, which also are administered by elected councils. At the lowest level of sub-national governance are municipalities and townships. In 2006, councils were in place in all 18 governorates,

[50] This section is extracted and summarized from "Republic of Iraq: National Development Plan for the Years 2010-2014 (Ministry of Planning, 2010)".
[51] The Iraq Briefing Book (The Iraq Partners Forum, 2010).
[52] Annual Abstract of Statistics 2008-2009 (Central Organization for Statistics and Information Technology, Iraq).

90 districts, and 427 municipalities and townships[53]. Kurdistan Autonomous Region is not accounted for a governorate.

Basic profiles of 18 governorates are shown in Table 5-4-15[54].

Table 5-4-15 Profile of Governorates

No.	Governorate	Capital	Area (km^2)	Population (2007)
1	Anbar	Ramadi	138,228	1,485,985
2	Babil	Hilla	5,119	1,651,565
3	Baghdad	Baghdad	4,555	7,145,470
4	Basrah	Basrah	19,070	1,912,533
5	Dahuk	Dahuk	6,553	505,491
6	Diyala	Ba'qubah	17,685	1,560,621
7	Erbil	Erbil	15,074	1,542,421
8	Kerbala	Kerbala	5,034	887,859
9	Kirkuk	Kirkuk	9,679	902,019
10	Missan	Amarah	16,072	824,147
11	Muthanna	Samawah	51,740	614,997
12	Najaf	Najaf	28,824	614,997
13	Ninewa	Mosul	37,323	2,811,091
14	Qadissiya	Diwaniya	8,153	990,483
15	Salah al-Din	Tikrit	24,075	1,191,403
16	Sulaymaniyah	Sulaymaniyah	17,023	1,893,617
17	Thi Qar	Nassiriyah	12,900	1,616,226
18	Wassit	Kut	17,153	1,064,950

Note: The names with underlines are the ones where the large thermal plant candidate sites exist.

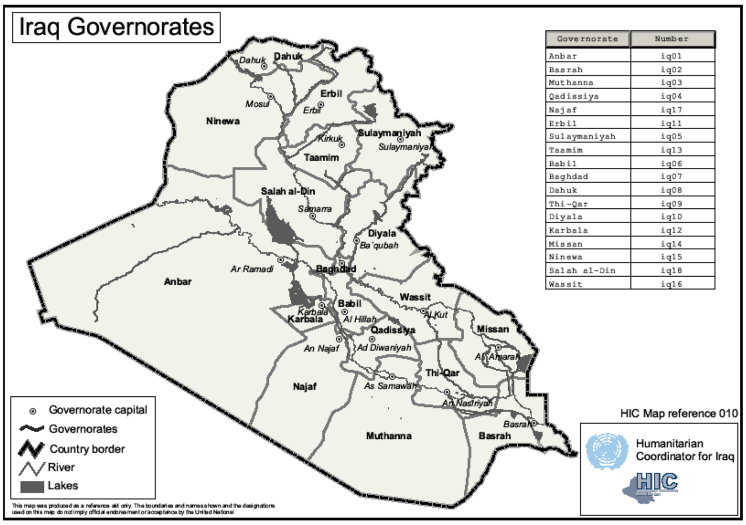


Figure 5-4-9 Administrative Boundaries in Iraq[55]

[53] Extracted from "Country Profile: Iraq (Library of Congress – Federal Research Division, 2006)".
[54] IAU – Iraq Information Portal: http://www.iauiraq.org/gp/
[55] United Nations Assistance Mission for Iraq - Map Centre : http://www.uniraq.org/library/maps.asp

(c) Industrial activities[56]

Agriculture: The total of arable land, irrigated land, and dry land in Iraq is 44.46 million acres (= 179,700 km^2). The total area of that land available for irrigation is 22.86 million acres of which 13.24 million acres are actually irrigated. A large part of the land is in poor condition because of salinity and the fact that it is filled with ground water, especially in the central and southern areas because of bad operational works, poor maintenance, and lack of integrated water logging. Natural factors are still the main influences on determining the production levels and harvests of the main crops in Iraq.
In 2005 the main agricultural crops were wheat, barley, corn, rice, vegetables, dates, and cotton, and the main livestock outputs were cattle and sheep[57].

Forestry: In 2005, forests are almost exclusively confined to the northeastern highlands. Most of the trees found in that region are not suitable for lumbering. In 2003, 113,000 m^3 of wood were harvested, nearly half used as fuel.

Fishing: Despite its many rivers, Iraq's fishing industry has remained relatively small and based largely on marine species in the Persian Gulf. In 2002 the catch was 14,500 tons.

Mining and Minerals: Aside from hydrocarbons, Iraq's mining industry has been confined to the extraction of relatively small amounts of phosphates (at Akashat), salt, and sulfur (near Mosul).

Manufacturing: Traditionally, Iraq's manufacturing activity has been closely connected to the oil industry. The major oil-related industries have been petroleum refining and the manufacture of chemicals and fertilizers. Since 2003, security problems have blocked efforts to establish new enterprises. An exception is the construction industry, which has profited from the need to rebuild after Iraq's several wars.

Oil and Gas: Oil and gas were discovered in Iraq in the early 1900s and have become among the most important sources of energy and a main source of financial resources to the national economy. In 2004, daily crude oil production reached 1.995 million barrels/ day. It rose to 2.285 million barrels/day in 2008. Despite that, it could not reach 1979 production rates, which were at a record high of 3.563 million barrels/day. Export of crude oil increased 1.535 million barrels/day in 2004 to 1.849 million barrels /day in 2008. During some months of 2009, oil exports reached two million barrels/day, despite damage and vandalism to the basic oil export infrastructure. In gas activity, 40.9 % of the gas produced is burned before becoming available for use. This constitutes a significant loss to the national economy and a source of environmental pollution. The vision is set up as follows: to increase production capacity in the fields of oil, gas, and oil products pursuant to international specifications, and to increase oil and gas reserves, thereby ensuring longevity of Iraq's advanced position among producers and exporters worldwide, while utilizing these resources in a sustainable manner to protect the environment.

Electricity: Refer to Chapter 2.

---

[56] This section is extracted and summarized from "Republic of Iraq: National Development Plan for the Years 2010-2014 (Ministry of Planning, 2010)". "Forestry", "Fishing", "Mining and Minerals" and "Manufacturing" are from "Country Profile: Iraq (Library of Congress – Federal Research Division, 2006)".
[57] "Country Profile: Iraq (Library of Congress – Federal Research Division, 2006)".

(d) Infrastructure: roads /bridges, railroads and ports[58]

Roads / bridges: This activity falls within the purview of the General Authority for Roads and Bridges within the Ministry of Construction and Housing. The total length of the external road network (beyond the boundaries of municipalities and the Mayoralty of Baghdad) is approximately 48,000 km, comprising: highways, 1,084 km; arterial roads, 11,000 km; rural roads, 10,000 km; border roads, 11,000 km; and secondary roads:15,200 km. In addition, there are 1,247 concrete and steel bridges and 35 floating bridges scattered throughout the country's provinces. This network does not meet the country's needs, particularly with respect to rural roads.

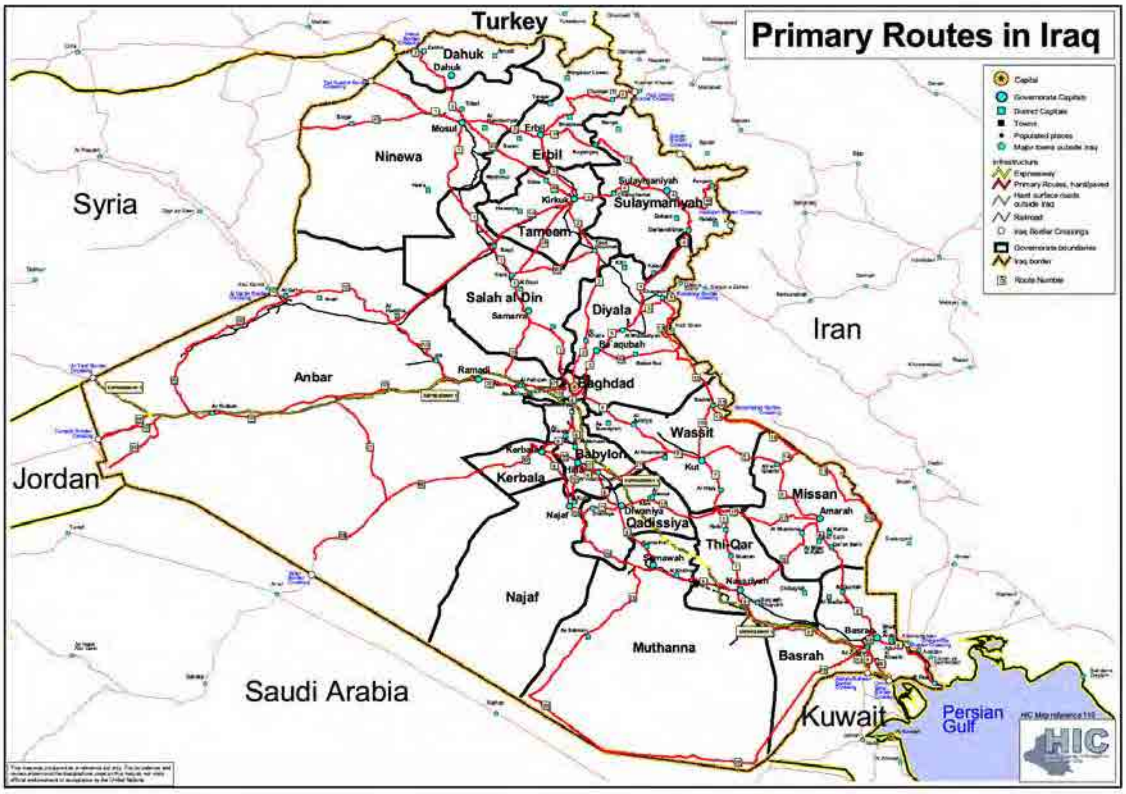


Figure 5-4-10 Primary Road Map of Iraq[59]

Railroads: In 2008, Iraq's railroad lines totaled 2,295 km, of which 1,901 km were main lines, and 394 km were secondary lines. The number of locomotives in operation was 106, down from the 494 originally constructed. Lines currently in operation are Baghdad–Basra, Baghdad–Samarra, Mosul–Rabia, and Baghdad–Fallujah. Work is currently being done to double the Baghdad–Basra, the Baghdad–Mosul, and the Hammam Al-Alil–Sabonia–Rabia lines, and to modernize and renovate existing lines to increase their efficiency, increase operating speeds, and improve line capacities.

Ports: Basra is Iraq's only international port and is of vital economic importance in securing a large portion of Iraq's import needs and a key port for exporting crude oil and other Iraqi products. Port activities are funded and managed entirely by the state through the General Company for Iraqi Ports.

---

[58] This section is extracted and summarized from "Republic of Iraq: National Development Plan for the Years 2010-2014 (Ministry of Planning, 2010)".
[59] United Nations Assistance Mission for Iraq - Map Centre : http://www.uniraq.org/library/maps.asp

Currently, Iraq has four commercial ports and two platforms to export oil. There are 48 commercial port docks with a capacity of 17.5 million tons annually, of which 43 are currently operational with a capacity of 15.90 million tons annually.

(e) Water resources[60]

The water resources of Iraq are strongly connected with the quantity of rain and snow that fall in the main river basins (Tigris and its tributaries and Euphrates) and the policy of using the dams and reservoirs that are built on upper parts of the mutual rivers in Turkey, Syria, and Iran. Its quality deteriorates because it is kept in reservoirs and polluted water is discharged into them from various industrial agricultural and human activities. Iraq will witness more shortages in water resources and low quality after Turkey completes its irrigation projects and Syria develops its irrigation projects. This will cause a deficiency in revenues from the Tigris and Euphrates of more than 43 % in 2015. The Ministry of Water Resources is updating the water budget of Iraq (comprehensive planning of water and land), and will establish policies related to managing and investing the water resources.

Table 5-4-16 shows the decline of the discharges of Euphrates and Tigris Rivers.

Table 5-4-16 Average annual river inflow to Euphrates and Tigris Rivers at the borders[61]

	Until 1989	1990-2005	Until 2014 (planned)
Euphrates River	27.4 BCM	17.4 BCM	8.5 BCM
Tigris River	NA	19.4 BCM	9.2 BCM

BCM = billion cubic meters, NA = not available

A technical report on municipal water supplies62 estimates that, in Basra Province, a present total peak daily water demand of about 650,000 m3/day rising to 1,167,400 m3/day by 2025, assuming that the population of the province is projected to rise from 1,761,000 in 2003 to 3,375,000 in 2025. The water demand includes domestic, commercial and industrial ones.

(f) Socially vulnerable people

Persons with disabilities: Despite the survey by the government, the number and distribution of disabled persons are not available yet.

Widows and Orphans: There are large discrepancies in estimates of the numbers of widows and orphans. The report of the United Nations on human rights in Iraq in 2006 has shown that women and children are still paying a high price as a result of domestic disputes, violence, and terrorism and that the number of orphans and widows is increasing continuously.

Displaced Families: Difficulties what Iraqi displaced families are mainly in the countries of emigration as many family's savings are depleted because of the high cost of living and the lack of work opportunities. Those families have lost their main source of support because of circumstances in the countries of emigration.

---

60 The following sections (Water resources, Health, Socially vulnerable people and Poverty) are extracted and summarized from "Republic of Iraq: National Development Plan for the Years 2010-2014 (Ministry of Planning, 2010)".

61 The Preparatory Survey on South Jazira Irrigation Project in Republic of Iraq (JICA, 2011)

62 Strategy For Water and Land Resources in Iraq/ Technical Report Series: Municipal Water Supplies (Ministry of Water Resources, 2006, Preliminary report)

Children: Children (those under 18) form approximately half of the population of Iraq. Children in Iraq, as in all conflict zones, are the victims mostly liable to violate the law. Despite laws that require children to enroll at schools, the crises have forced many families to work outside the home.

(g) Poverty

The document of the strategy for decreasing poverty that was approved by the cabinet in November 2009 indicated that 22.9 % of citizens, or approximately 6.9 million Iraqis, are below the poverty line (77 thousand dinar/individual/month).

The distribution of poor people differs between rural and urban areas. While 70 % of the citizens live in the urban areas, half of the poor are concentrated in rural areas. This suggests that the economic and social conditions in the rural create an environment that generates poverty.

(h) Ethnic groups

In 2006 an estimated 75 to 80 % of the population was Arab and 15 to 20 %, Kurdish. Other significant minority groups, together constituting less than 5 % of the population, were Assyrians, Chaldeans, and Turkmens[63].

The Marsh Arabs are known as a group who lives in the southern part of Iraq, especially in the marshlands, and also known as socially vulnerable people. According to UNEP[64], in 2003, about 10,000 Marsh Arabs live in the marshlands in southern Iraq, and 10% of them live in their traditional way of life.

(i) Historical and cultural heritages

Iraq currently has three (3) World Heritages and has proposed 11 archaeological and natural sites for as candidates of the World Heritage as follows. The detailed information such as their locations is shown in Attachment - 13.

- World Heritage Sites
  - Hatra (Date of Inscription: 1985)
  - Ashur (Qal'at Sherqat) (Date of Inscription: 2003)
  - Samarra Archaeological City (Date of Inscription: 2007)
- Proposed World Heritage Sites
  - Ur (Date of Submission: 07/07/2000)
  - Nimrud (Date of Submission: 07/07/2000)
  - Ancient City of Nineveh (Date of Submission: 07/07/2000)
  - Fortress of Al-Ukhaidar (Date of Submission: 07/07/2000)
  - Wasit (Date of Submission: 07/07/2000)
  - Sacred Complex of Babylon (Date of Submission: 29/10/2003)
  - Marshlands of Mesopotamia (Date of Submission: 29/10/2003)
  - Erbil Citadel (Date of Submission: 08/01/2010)
  - Site of Thilkifl (Date of Submission: 21/01/2010)
  - Amedy City (Date of Submission: 02/02/2011)
  - Wadi Al-Salam Cemetery in Najaf (Date of Submission: 24/01/2011)

63 Extracted from “Country Profile: Iraq (Library of Congress – Federal Research Division, 2006)”.
64 Environment in Iraq: UNEP Progress Report (2003).

5.4.4 Description of the Environments around Nasiryah II

(1) Physical and natural environments

(a) Geographical features and its vegetation

The site is located in “Lower Mesopotamia” biogeographical region (refer to 5.4.3), and the Photo 5-4-1 shows the current status of the site. Some shrubs are observed in the surrounding area.

Photo 5-4-1 Photograph of the site (provided by MOE)
The thermal power plant behind the site is Nasiryah Thermal Power Plant

(b) Climate

The site is located in “Hot desert climate” (refer to 5.4.3) which has low precipitation and high temperature in summer and low temperature in winter. Figure 5-4-11 shows average rainfall, and Figure 5-4-12 shows average temperature at Nasiryah Meteorological Station. The prevailing wind direction is north-west and north-west/north according the record of Nasiryah Meteorological Station.

The details of the meteorological data of the site are described in “5.1.1 Meteorological Condition”.

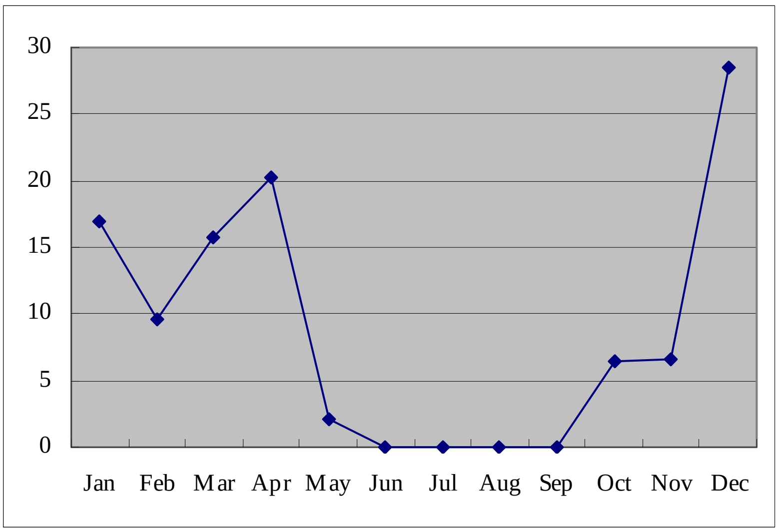


Figure 5-4-11 Average rainfall at Nasiryah Meteorological Station (2000-08, unit: mm)

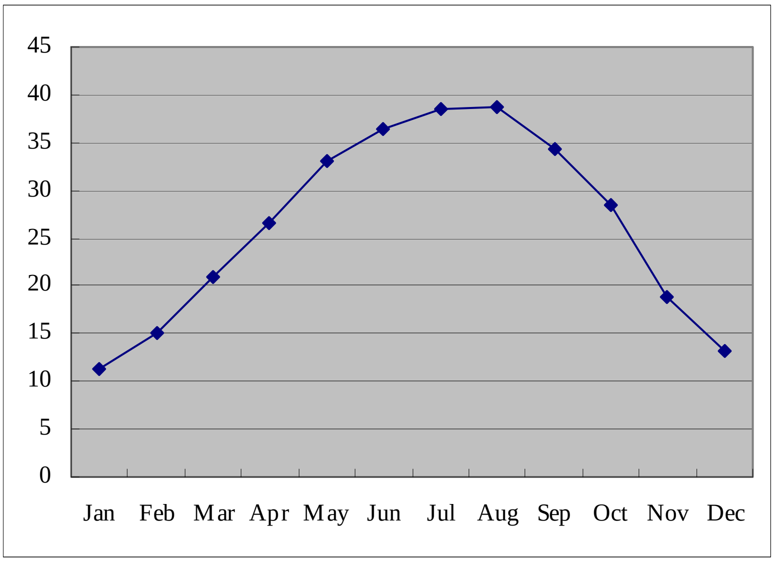


Figure 5-4-12 Average temperature at Nasiryah Meteorological Station (2000-08, unit: deg C)[65]

(c) Terrestrial and freshwater ecosystems

The site and its surrounding area belong to Tigris-Euphrates alluvial salt marsh eco-region and "Lower Tigris & Euphrates" freshwater eco-region (refer to 5.4.3).

The site has been prepared for an industrial area and its vegetation is very poor (Photo 5-4-1). Euphrates River runs along the Nasiryah Thermal Power Plant. 47 fish species are listed as freshwater fish in Iraq[66] (Attachment - 13) but the detailed data of the river around the site is not available.

(d) Important Bird Areas

There are not any IBAs close in the vicinity of the site (see Figure 3-1-2 and Attachment - 11).

(e) Endangered species

It is assumed that endangered species categorized by IUCN (see Attachment - 12) do not occur in the site and its close vicinity because of the following reasons: the site is not a suitable habitat (e.g. large mammals such as Asiatic Wild Ass, waterbirds such as Lesser White- fronted Goose); it is out of original distribution area (e.g. Iraqi Keel-scaled Gecko); and it is in the vicinity of a large city (Nasiryah) and the existing thermal power plant.

(f) Natural Protected areas

Proposed Mesopotamia Marshlands National Park (Figure 5-4-6) is located downstream of Euphrates River. The boundary of the above-mentioned proposed national park has not been drawn but the distance from Nasiryah II is about 50 km.

(g) Seismic status

The site is not located in an area prone to earthquake (refer to 5.4.3).

---

65 Figure 6-9 and 6-10 are prepared by the JICA Study Team based on the date provided by MOE.
66 Fishbase: http://www.fishbase.org/home.htm

(h) Flood and geological conditions

The detailed descriptions on flood and geological conditions are presented in “5.2.2 Investigation Results”.

(i) Conditions of Euphrates River

The detailed descriptions on Euphrates River (e.g. water flow) are presented in “5.2.2 Investigation Results”.

(j) Environmental baseline data

Environmental baseline surveys were conducted from 26 to 18 September 2011, and their results are presented in “5.2.2 Investigation Results”.

(2) Social environment

(a) Administration[67]

Thi Qar Province is located in the south east of Iraq, north-west of Basra. The area of the province is 12,900 km2 (3% of the area of Iraq).

The Province (or governorate) is divided into 25 administrative units made up of:

- 5 counties (Qadha in Arabic) including (Nasiryah, Al Rifa’i, Suq Al-Shoyokh, Al- Chibayish and Al-Shatra. Figure 5-4-13 shows these counties.
- 5 county centers (cities)
- 15 districts (Hay in Arabic)

Nasiryah county consists of one city and four districts: Nasiryah City, Al Islah, Al Bathaa, Sayid-dakhil and Awr districts. There many settlements called Hay (in Arabic) under district and city. In the area of the project site, there are Hay namely Ur, Sumer 1, Sumer 2, Al Tadhyah, Al Askarei, Al Hussaien,Aredo, Al Sader, Al Shuhada, Al Edarah Al Mahaliyah, Al Salhiyah, Al Mansoriyah, Thermal Power Plant 1 residential area, Al Emarat, Aluminum residential area, Al Iskan Al Sina’aei, Al Saiednawiyah, Al Shualah and Al Dhubat.

Nasiryah City is the capital city of the Thi Qar Province, and was founded in the middle of the 19th century to serve as a center for the province. It was named after its founder sheikh Nasser El-Ashkar, a leader of El-Muntafik tribe.

[67] The information of this section is from the following two sources: Development Strategy of the Thi Qar Province-Thi Qar Stragetic Plan 2007-2009 (Thi Qar Provincial Council), and Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).

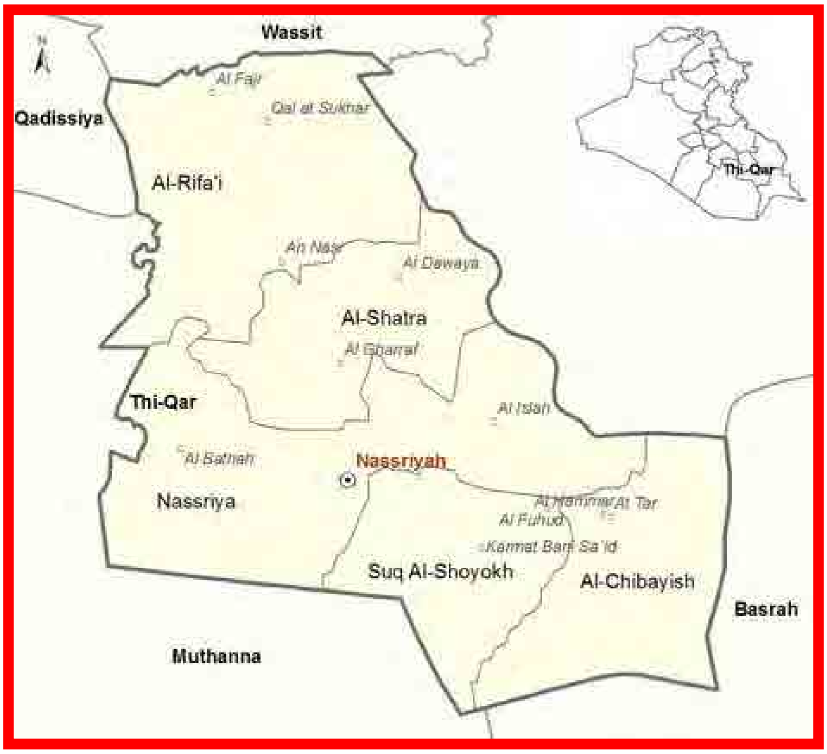


Figure 5-4-13 Thi Qar counties including Nasiryah county[68]

The project site is located in Al Awejah in Al Saiednawiyah Hay of Nasiryah City. There are two small settlements ("Qaryat" in Arabic) such as Al Sakheieen and Al Almeieen close to the project site. They are located in the opposite side of the Euphrates River (Figure 5-4-14).

Thermal Power Plant 1 residential area for the existing power plant employers is located at about one (1) km east of the project site and has the population of about 3,000[69].

68 The map is from Inter-Agency Information and Analysis Unit. http://www.iauiraq.org/default.asp

69 Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).

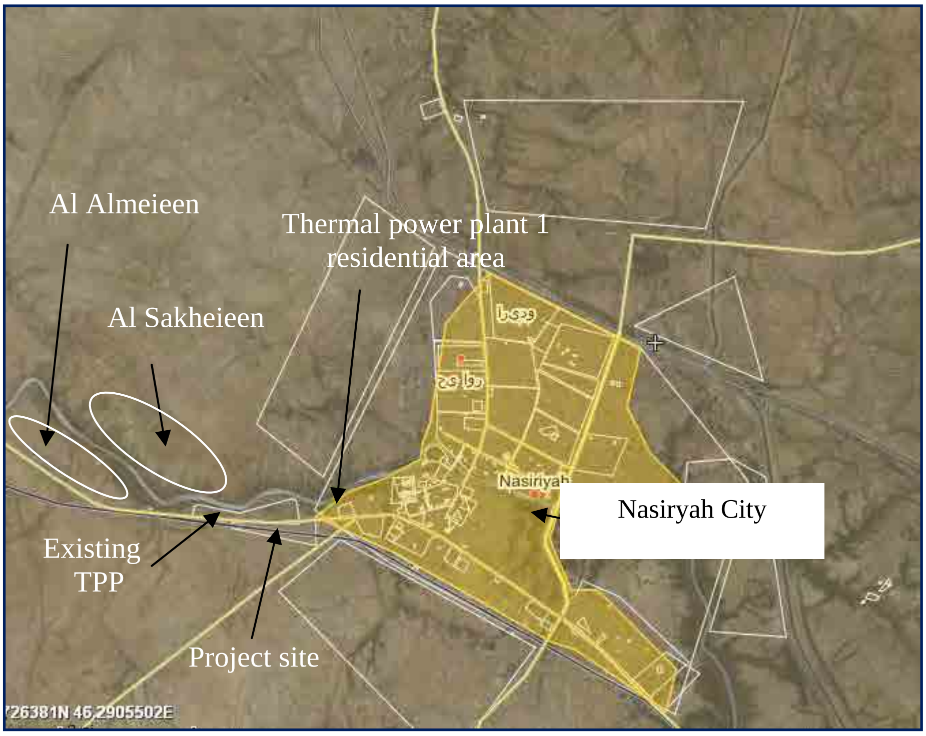


Figure 5-4-14 Settlements around the project site

(b) Population and demography[70]

The population of Nasiryah City is 478,889, represents 70.2 % of Nasiryah county and 26.5 % of Thi Qar Province. The mean household size is 7.5 persons.

The age and gender structure of Nasiryah City is a typical type of population with a historically high fertility. It is broadly based, with many children relative to adults. 42% of the population is aged less than 15 years. The dependency ratio, i.e. the ratio of the population aged below 15 and above 65 to the population aged 15 to 65, is 0.75. The gender ratio in the population, i.e. the ratio of males to females, shows a close to equal number of the two genders. There are a rather low number of men aged between 35 and 49-the year groups that were affected by losses during the Iran-Iraq war, and also by selective migration of males. The gender ratio drops with increasing age, a trait found in most populations, because women generally live longer than men.

The province is made up of rural and urban classes, each with its own intrinsic features. Family in the rural areas is sizeable and demonstrates tremendous help in farming labor. The family size in the city varies from one district to another: some include large families while some with specific features are home to smaller ones. The province is characterized by a tribal system. In the cities, a great deal of citizens' life is primarily regulated by a mix of modern law and other traditions.

(c) Livelihoods[71]

Although the economy of some provinces such as Basra is mainly based on the refining and export

[70] Information of this section is from Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).

[71] The information of this section is from the following two sources: Development Strategy of the Thi Qar Province-Thi Qar Stragetic Plan 2007-2009 (Thi Qar Provincial Council), and Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).

of oil and chemicals and the commerce of merchants through the ports, construction and trade in electrical goods have been considered growth sectors for employment in Thi Qar Province since 2003.

Economic performance is weak due to the lack of advanced means of production and public services, as well as the absence of paved roads connecting regions in the province. Although the aluminium, textiles, electrical cables factories and the existing power plant in the Province are functioning, the regional economy of the province has been affected by the closure of state-owned enterprises and reduction in public sector employment.

Agriculture also forms another important employment sector. The province is famous for the cultivation of cereals, vegetables, rice and oases of palm trees. It has also significant livestock, including sheep, cattle, goats, camels, cows and other herds.

Unemployment in the province is estimated by local officials to be 31% (15%, national average). The shortage of employment opportunities in the province as well as the large number of unemployed men has meant that Ministry of Labour and Social Affairs is unable to find jobs for the majority of people registered. Although salaries have generally increased since 2003, the disposable income has not increased to the same extent, because benefits have been cut in some sectors and living costs have increased.

25% of the households in Nasiryah City are unemployed while the rest of 75% relies on one or two sources of income. 50% of the households with employment derive the livelihood by wage income in form of work in electricity, gas, water supply and oil industry respectively public administration, defense, education, health and social work. The other 25% of the households derive their income by self-employment like construction, wholesale and retail trade, repairs and transport. The unemployed households, depend for their living on food ratios, fishing for own consumption[72], in kind assistance in form of food ratios. Beside the above mentioned, all households receive food ratios such as rice, sugar, flour, tea, detergents and oil from the Ministry of Trade.

The province performs poorly according to many humanitarian and developmental indicators. 32% of the population lives below the national poverty line (US$ 2.2 per day). Since low education levels are a major problem among women: outside Nasiryah City, 6% of rural women aged 15-64 years are economically active.

(d) Transportation[73]

The roads in the province are well used, even though most are damaged or in disrepair. Roads in rural areas are predominantly unpaved (90%) and maintenance usually falls to local communities or district councils who have limited funds for repairs. Two major road pass through Nasiryah City: Basra-Bagdad Highway and Nasiryah-Samawah road.

(e) Communication systems

The national Iraqi telephone land lines are operating in the province for calls across Iraq but not for international calls. Mobile phones are the preferred form of telephone communication because these have the ability to make international calls. Internet service providers offer private internet connections in Nasiryah City, leading to the development of numerous Internet Cafés there. Mobile phone subscribers per 100 residents is 73.2 and the ratio of household owning a personal computer is 5.7%.

(f) Water supply

In the province, the main water source to supply water drinking treatment plants is rivers and streams especially Euphrates and Al Bada'a rivers.

---

[72] The information from MOE also indicates that there is no commercial fishery around Nasiryah II.

[73] Information of (4), (5) and (6) is from Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).

The most of Nasiryah's households have a connection to the existing water network. However, the piped water is unsafe and not useable as drinking water due to the high percentage of salinity. Thus, the some of the Nasiryah's households rely on small RO units for drinking water. Some of the rural areas have small package units installed in the Euphrates River to supply water to these small settlements (Qaryat), while other Qaryat use trucks to bring water to them. The access to water supply is extremely poor outside Nasiryah City.

(g) Electricity supply[74]

The electricity supply is generally very good in the province, with the exception of Rifa'i county.

(h) Sanitation facilities

While 80% of all households in Nasiryah City own toilets located in their accommodations, the other 20% use outdoor toilets. The city government has two wastewater treatment plants. One has 18,000 m3/day design capacity, and the other one has 4,000 m3/day capacity. There are 11 pump sewer stations, and 41 storm water pump stations[75].

The province sustains a shortage of sewerage networks, especially in the counties and districts. In Nasiryah City, areas benefiting from a sewerage system do not exceed 6%, and areas served by with a water treatment system (rain water) constitute 10%[76].

(i) Waste disposal system

The province suffers an increase in the quantity of waste accumulated in the streets and squares. Additionally, dumps violate environmental standards, and used equipment is old and insufficient. The province and Nasiryah City have no system for waste disposal[77].

At the existing Nasiryah TPP, suspended solid in the river water such as mud is plugged the condenser tubes and therefore periodically removed. The removed mud is planned to be recycled as a gardening material (i.e. fertilizer). Treated oil from oil contaminated water is sent to MOO factory to be recycled as miscellaneous oil such as brake oil[78].

(j) Health status and medical centers

The southern region of Iraq is adversely affected by water pollution, air pollution (burning oil wells) and by depleted uranium contamination (warheads), representing the most serious impact on people's health. Also, the region suffers from airborne lead and soil contamination due to the negligent use of chemical fertilization[79].

People in Nasiryah City suffer from chronic health problems, dermatitis and respiratory system disease due to worsened living and sanitation conditions. The under-five mortality rate is 41 for every 1,000 births, and the ratio of tuberculosis is 12.4 for every 100,000 of the population[80].

Three major medical centers exist in Nasiryah City: namely Al Husain Educational Hospital, Bint Al Huda Hospital for Children and Women and Al Nasiryah Center for Heart Surgery. They are

74 Information is from Inter-Agency Information and Analysis Unit. http://www.iauiraq.org/default.asp
75 Statistics of water in Iraq (Central Organization for Statistics and Information Technology, Ministry of Planning, 2008).
76 Development Strategy of the Thi Qar Province-Thi Qar Stragetic Plan 2007-2009 (Thi Qar Provincial Council).
77 The information of this section is from the following two sources: Development Strategy of the Thi Qar Province-Thi Qar Stragetic Plan 2007-2009 (Thi Qar Provincial Council), and Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).
78 Information from General Manager of the existing Nasiryah TPP.
79 Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).
80 Inter-Agency Information and Analysis Unit. http://www.iauiraq.org/default.asp

about 5 km from the project site. Also there is small medical center in each Hay of the city. The health system in the city is affected by a lack of health personnel, lack of medicines, non-functioning medical equipment, damaged facilities, disrupted electricity supply, lack of adequate sanitation, and lack of communication systems[81].

(k) Education

The primary indicators of educational conditions of Nasiryah City are summarized in Table 5-4-17.

Table 5-4-17 Primary indicators of educational conditions of Nasiryah City[82]

Indicator	Percentage
Net enrollment ratio in primary education	77.9
Net enrollment ratio in secondary education	15.8
Enrollment ration females to males in primary education	81.7
Prevalence of illiteracy (aged 10 years and above)	16.5

(l) Ethnicity

The predominant religion in Thi Qar Province is Islam, with more than 97% of the population in the province constituting the Shii branch of Islam. Additionally the province has Sunni, Mandaean, Chaldean and Assyrian Christian communities making out about 3%. All contribute to the province's rich cultural history.

Tribes from across Mesopotamia and the Middle East have migrated through the area over the centuries, creating a diverse tribal ancestry. Tribes currently present in the province are summarized in Table 5-4-18. In 1991, a large number of residents in Kuwait immigrated to the province to join their fellow clansmen.

Table 5-4-18 Tribes in the province and the most predominant ones in Nasiryah City

Tribes		Tribes	
1	<u>Beni Malek</u>	14	<u>Al Ajwed</u>
2	Albu Salih	15	Ghazyah
3	Alaliat	16	Khafagah
4	Al Hasan	17	Al Sharefat
5	Hejam	18	<u>Al Badoor</u>
6	Beni Asad	19	Al Zhaeeryah
7	Ibadah	20	<u>Al Hosenat</u>
8	Beni Saeid	21	Aboodah
9	<u>Al Azereg</u>	22	Al Masoom
10	Albu Nasir	23	Al Sadoon
11	Albu Awaed	24	Al Imara
12	Albu Awafey	25	<u>Al Shamar</u>
13	Albu Hameedah	26	Zairaj

* Names with underline are the predominant tribes in Nasiryah City

81 Statistics Directorate of Thi Qar Governorate (Ministry of Planning, 2010).
82 Inter-Agency Information and Analysis Unit. http://www.iauiraq.org/default.asp

5.4.5 Discussion of Alternatives

(1) Zero option

Considering that the electricity supply currently only meets about 70 % of the demand in Iraq (refer to 2.2.1), the Project has a role to fill the gap (30 %) for the development of the country. "Zero options" of the Project need to fill the above-mentioned gap and there are a) to develop other electric energy sources: renewable and/or nuclear energy sources; b) to purchase electricity from neighboring countries.

(a) Other electric energy sources

Regarding the renewable energy source such as hydroelectric power generation, its development potential is very small. Hydroelectric power generation faces the scarcity of water and its effects on operating hydroelectric stations[83], and wind and solar power generations generally are unstable and cannot supply base load of the electricity. There is no development plan for nuclear power station[84].

(b) Import of electricity from the neighboring countries

Iraq Electricity Master Plan (2011) states that total of 1,000 MW can be imported from the neighboring countries after 2012, and other than that there is no plan of importing electricity.

Regarding generation types in the neighboring countries, they also depend on thermal power generation to meet their electricity demands since the potential of hydroelectricity development is basically low in the Middle East. It means that, even if Iraq imports the electricity, environmental impact from the global point of view (mainly CO_2 emission) would be similar to the one of thermal power generation development in Iraq.

If either "Zero option" is selected, Iraq will continuously face electricity power shortage. Thermal power plant is, therefore, the only electricity power source which will be able to supply almost all electricity to the country.

Regarding CO_2 emission from the plant, it is inevitable that the total CO_2 emission will increase. The Project optimizes fuel selection and configuration of gas turbine combined cycle system to reduce its emission as much as possible.

(2) Site Selection

"Large Scale Thermal Power Plant Site Selection Study in Southern Iraq (2008)" identified 17 sites of the development of a large scale thermal plant to meet the power demand of Iraq. Based on these information the Study Team conducts the following site selection exercise (refer to Chapter 3 for more detailed description).

The process of the exercise is described in the following diagram.

[83] Republic of Iraq: National Development Plan for the Years 2010-2014 (Ministry of Planning, 2010)
[84] Iraq Electricity Master Plan (Ministry of Electricity, 2011)

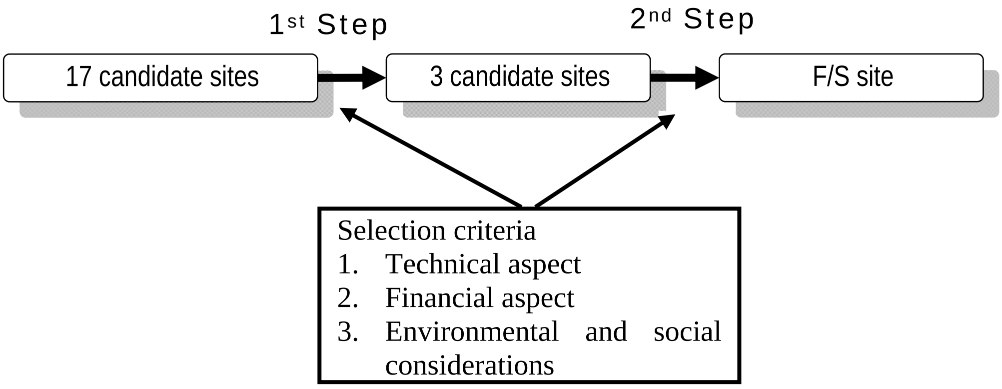


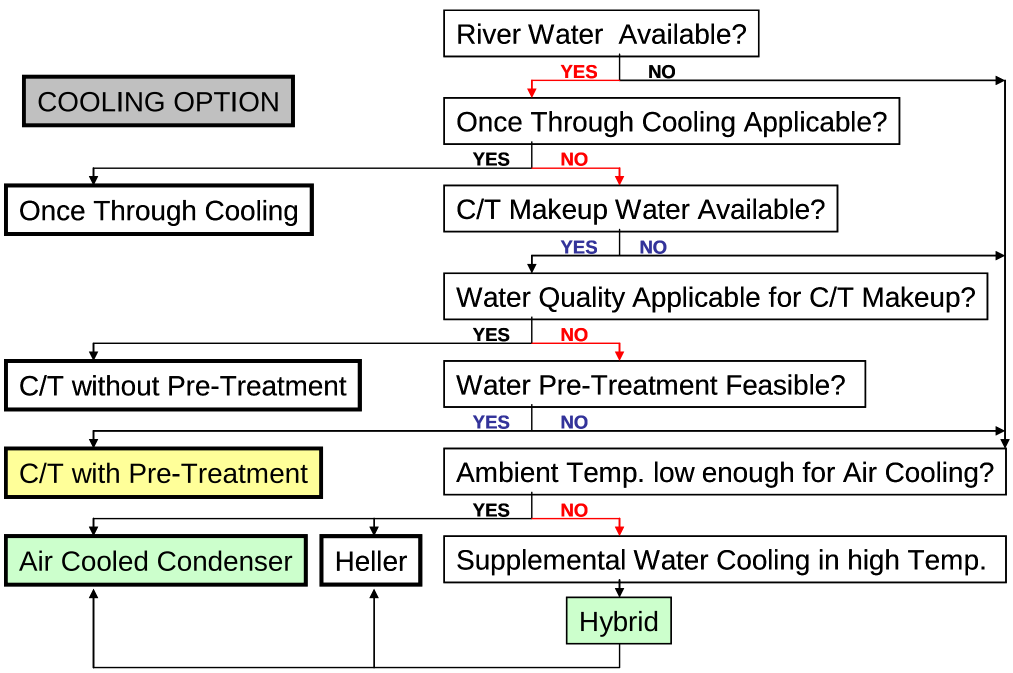
Figure 5-4-15 Site Selection Process

Exercising the 1st step, all locations of the Iraqi IBAs (refer to 3.1.1) are compared with the locations of 17 candidate sites. All 17 candidate sites are out of or far from the IBAs (refer to Appendix 5-4-1).

As a result of the examination, Nasiryah II is selected as the F/S site of the Project.

(3) Selection of cooling system for Nasiryah II

Steam turbine condenser cooling options are compared from technical, economical and environmental points of view. Regarding the environmental aspect, the following points are considered: decline of the entire water discharge of the Euphrates and Tigris Rivers, increase of water consumption, and important marshlands downstream. Figure 5-4-16 shows the flowchart of the comparison exercise of the options.



CT: cooling tower

Figure 5-4-16 Flow of comparison exercise of cooling options

(a) Once through cooling option

It is rejected because of the national policy of Iraq; once through cooling is not allowed for newly constructed thermal power plant.

(b) Cooling tower (C/T) without pre-treatment

It is rejected because of high salinity level of Euphrates River. Its TDS value ranges from 2,860 to 2,900 (Table 5-2-12) and this water quality may cause damage to cooling tower.

(c) C/T with pre-treatment

Although it is once considered as the optimal option for the Project, it is finally rejected because of decline of water of Euphrates River (refer to Table 5-2-12, Table 5-4-16 and Figure 5-2-8).

(d) Heller

It is rejected because of cost and its requirement on area.

(e) Hybrid Air cooled condenser

Air cooled condenser (ACC) is selected since it does not require water. However the region of the Project record high temperature (over 40 °C) during day time in summer, the efficiency of the function goes down. Therefore Hybrid air cooled condenser (Hybrid ACC) is considered as the cooling option for the Project. Hybrid ACC sprays water for cooling down the air only when high temperature (over 40 °C) is recorded. It requires much less water than C/T option.

Table 5-4-19 shows the water requirements of C/T and Hybrid ACC are compared: raw water from river (1st row).

Table 5-4-19 Results of the comparative study of water flow of C/T and Hybrid ACC

(the water flow is calculated per train)	**C/T water flow (unit: t/h)**	**Hybrid ACC water flow (unit: t/h)**
Raw water from river	1,500	470
Pre-treatment back-wash and rejection water	306	96

The estimated water requirement volume of the Hybrid ACC is under the condition of 50 °C. It indicates that water requirement under other conditions (e.g. at 40 °C) is much less than the figure shown in Table 5-4-19. This is because no spray water is required under 40 °C. According to the climate data around Nasiryah, high temperature (over 40 °C) is usually recorded from May to September, and it is recorded only day time. The time duration that requires spray water is therefore short.

The raw water from the Euphrates River is desalinized through RO system, and rejection water is discharged to the river. Because of the high salinity of the raw water (c. 3,000 TDS value), the rejection water has higher salinity (i.e. 6,000 – 9,000 TDS value). Table 5-4-19 compares the discharge water of C/T and Hybrid ACC: pre-treatment back-wash and rejection water (2nd row). The estimated discharge water from the Hybrid ACC is less than the C/T. The Hybrid ACC therefore is identified as “the least water consumption and the least waste water discharge” system, and selected as the cooling system of Nasiryah II.

For the Hybrid ACC, 54 cells of fin-fans are planned to be installed for each steam turbine. Since the plot plan is design to have enough distance (50 m)[85] from the facility to the site boundary, the

[85] A study in India indicates that the noise level from an ACC reduces to 70dB at the point of 50 m from the ACC (ENERGO Enginnering Projects Limited, 2009).

noise from the cells is expected not to exceed the standards (70 dBA).

Considering the above-mentioned points, the Hybrid ACC is selected as the cooling system for Nasiryah II.

(4) Selection of generation and fuel types for the Nasiryah II

The following three generation types are considered to meet the Master Plan 2010 for the Nasiryah II: combined cycle (CC); gas turbine (GT); and steam turbine (ST). The study to compare the three generation types is conducted (refer to Chapter 4).

Table 5-4-20 shows the results of the comparative study of the three generation types.

Table 5-4-20 Results of the comparative study of the three generation types

		Combined cycle (CC)	Gas turbine (GT)	Steam turbine (ST)
Output		1,800MW	1,800MW	1,800MW
		900MW x 2	300MW x 6	600MW x 3
Minimum output		450MW (50% of 1 train)	150MW (50% of 1 GTG)	180MW (30% of 1 unit)
Fuel		Natural gas	Natural gas	Residual oil
Fuel cost (USD/Million BTU)		5	5	16
Construction cost (USD/kW)		742	561	894
O&M cost	Fixed (USD/kW/year)	14.6	43.8	51.2
	Variable (USD/MWh)	3.11	12.4	3.51
Life (years)		25	25	25
Efficiency at rated net output (%)		57.3	38.7	41.0
Forced outage rate (%)		6	33	6
Scheduled outage (days/year/unit)		21	12	34
CO_2 emission (million kg-CO_2)		4,447	6,584	8,124
Unit CO_2 emission (kg-CO_2/kWh)		0.35	0.52	0.64

Table 5-4-21 shows relative emissions rate from each fuel type. CC uses natural gas and natural gas has better environmental features than oil and coal.

Table 5-4-21 Emissions from each fuel type[86]

	Natural gas	Oil	Coal
NOx	20 - 37	71	100
SOx	Nil	68	100
Note: The value of each pollutant is NOT absolute one but relative value comparing the one of the coal.			

In conclusion, CC has better performances in technical, financial and environmental aspects than other two generation types, and CC has been selected for Nasiryah II.

[86] Agency for Natural Resources and Energy, Japan (2010), White Book on Energy (in Japanese)

5.4.6 Support for Preparation of EIA and Environmental Checklist

(1) Rationale for Preparation of EIA

Establishment of a gas power station is categorized as Class B under the Iraqi law (No. 29 of 2009), and it is required to go through the environmental impact assessment process to obtain an Environmental Compliance Certificate from MOEN (refer to 5.4.2).

JICA also has its guidelines on an EIA study for its supporting project, and according to its guidelines[87], the Project is categorized as Category A which requires a comprehensive EIA study and a report.

It is therefore an EIA study is conducted for the Feasibility Study on Nasiryah II Thermal Power Plant under both the Iraqi law and the JICA guidelines.

(2) Discussions with MOE on Preparation of EIA

At every mission of the Study, both MOE and the Study Team discussed the implementation of EIA Study and preparation of the report. The contents of the meetings are summarized in Table 5-4-22.

[87] Japan Bank for International Cooperation (JBIC): Guidelines for Confirmation of Environmental and Social Considerations (2002). Yen Loan activities are now conducted by JICA (not JBIC) and the guidelines (2002) is applied for this Project.

Table 5-4-22 Contents of the meetings on the preparation of EIA

Mission	Venue and month	Contents of Meeting
1st mission	Amman (Jordan), July 2011	Both parties agree on the following points: ▪ MOE will directly employ a local consultant to conduct the EIA Study. ▪ The institutional structure of the implementation of the EIA Study is shown as Figure 5-4-17.
1.5th mission	Amman, August	Both parties agree on the contents of the EIA Study, its report and the deadline of submission of the report to MOEN. The first draft of the scoping of the EIA Study is discussed.
2nd mission	Tokyo (Japan), October	The Study Team prepares the Terms of Reference of the EIA Study. Both parties agree on that MOE will contract an appropriate local consultant for the EIA Study by the 3rd mission.
3rd mission	Amman, November	Both parties agree on the following points: ▪ Roles and responsibility of MOE, the local consultant, Anbar University, and the Study Team. ▪ The final version of the Scoping (draft) of the EIA Study. ▪ Detailed schedule and outputs until the end of March 2012.
3.5th mission	Amman, January 2012	This mission is conducted to formulate the draft final report of the EIA Study. Both parties agree on the revised detailed schedule and outputs until the end of March 2012.
4th mission	Istanbul (Turkey), February	The final discussion on the EIA Report is conducted.

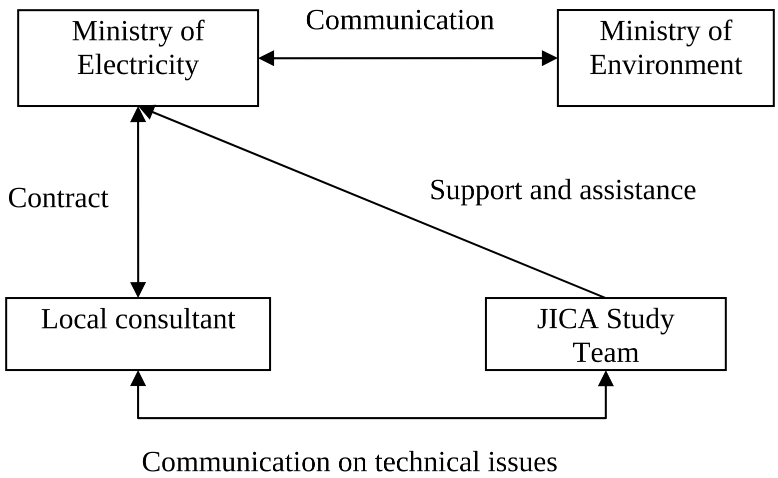


Figure 5-4-17 Institutional Structure of the Implementation of the EIA Study

(3) Contents of the EIA report

At the 1.5th mission, both parties agreed on the contents of the EIA report as of Table 5-4-23

Table 5-4-23 Contents of the EIA Report

Title	Description
Executive Summary	It concisely discusses significant findings and recommended actions.
Introduction	It concisely introduces the Project and the Report
Policy, legal and administrative framework	It discusses the policy, legal and administrative framework within which the EIA study is to be carried out.
Project description	It describes the Project and its geographic, ecological, social and temporal context, including any off-site investments that may be required.
Approach and Methodology	It describes the EIA methodology briefly.
Baseline data	It describes relevant physical, biological and socio-economic conditions, including all changes anticipated before the project commences. Additionally, takes into account current and proposed development activities within the project area but not directly connected to the project. Data should be relevant to decisions about the Project.
Analysis of alternatives	It systematically compares feasible alternatives to the proposed project site, technology, design and operation including the "without project" situation in terms of their potential environmental impacts. For each of the alternatives, quantifies the environmental impacts to the extent possible, and attaches economic values where feasible. States the basis for selecting the particular project design proposed and offers justification for recommended emission levels and approaches to pollution prevention and abatement.
Environmental Impacts	It predicts and assesses the project's likely positive and negative impacts, in quantitative terms to the extent possible. Identifies mitigation measures and any negative environmental impacts that cannot be mitigated. Explores opportunities for environmental enhancement. Identifies and estimates the extent and quality of available data, essential data gaps and uncertainties associated with predictions, and specifies topics that do not require further attention.
Environmental Management Plan (EMP)	It describes mitigation, monitoring and institutional measures (including their rough budgets) to be taken during construction and operation to eliminate adverse impacts, offset them, or reduce them to acceptable levels.
Consultation	It is record of consultation meetings, including consultations for obtaining the informed views of the affected people, local non-governmental organizations (NGOs) and regulatory agencies.
Conclusions	It describes the conclusions and recommendations derived from the discussions in the previous chapters. This chapter also describes a future schedule of the EMP according to the implementation schedule of the Project. It shall include review of the EMP, employment of staff for EMP implementation, periodical monitoring reports and other exercise.

(4) Local Consultant

At the 1st mission, both parties agreed that MOE directly employed a local consultant and the institutional structure of the implementation of the EIA Study (Figure 5-4-17). MOE contracts with Engineering Consulting Bureau, Anbar Univeristy, Iraq, as a consultant to conduct the EIA Study based on the Terms of Reference prepared by the Study Team.

The TOR is attached as Attachment - 14.

(5) EIA Report

After the 4th mission, MOE, Anbar University and the Study Team finalized the EIA Report attached as Attachment - 15. MOE will submit the EIA Report to MOEN by the end of March 2012.

(6) JICA Environmental Checklist

The JICA Environmental checklist and the monitoring form (draft) are prepared in close collaboration among MOE, Anbar University and the Study Team, and they are attached as Attachment - 16 and - 17. An TOR for surveys on air and noise is also drafted as Attachment -18.

The key permissions required for the construction and operation of Nasiryah II were investigated, and are shown in Table 5-4-24.

Table 5-4-24 Key permissions required for the construction and operation of Nasiryah II

Permission	Permitting Authority	Relevant Legislation	Role of Permission	Status
Land Permission	Ministry of Finance Ministry of Environment Ministry of Oil Ministry of Defense Other relevant authorities	-	Authorization and agreements to obtain and to use the land for MOE's planned thermal power plant (TPP) at the designated land. Before the final authorization by the Ministry of Finance, all relevant authorities are consulted to obtain their agreements.	In process.
Construction Permission (for power plant)	Ministry of Electricity Ministry of Planning	-	Authorization of constructing the TPP	In process, and the final decision will be made at the Parliament of GOI.
Construction Permission (for buildings)	Ministry of Electricity	-	Authorization of constructing buildings of the TPP	-
Environmental Permission	Ministry of Environment	Law No. 27 of 2009, Law on Environmental Protection and Improvement	Authorization of the environmental effects and their mitigation measures of development and operation of the Power Plant	To be obtained.
Operation Permission	Ministry of Electricity (National Dispatch Center)	-	Authorization of dispatching electricity to the national grid	To be obtained.
Water Allocation Permission	Ministry of Water Resources	-	Allocation of water quota of Euphrates River to Nasiryah II	Obtained on 21 February 2012

GOI: Government of Iraq

Chapter 6
Formulation of Implementation Program

Chapter 6 Formulation of Implementation Program

6.1 Implementation Structure

6.1.1 Implementation Structure of the Project

(1) Procedures and Milestones in Iraq Required for Completion of the Power-plant Construction

MOE has the following functions and procedures to materialize the Project:

(a) MOE/Planning & Studies Office identifies the project and it has to be confirmed by the Minister of Electricity;

(b) With the project identification, MOE will obtain permission to use the selected site for a new power plant from the Ministry of Environment and also the Ministry of Antiques and Tourism.

Note: Preparation of this Study Report is located in this step.

(c) With the permission for the site, MOE will obtain the confirmed budget from the Ministry of Finance and also the Ministry of Planning;

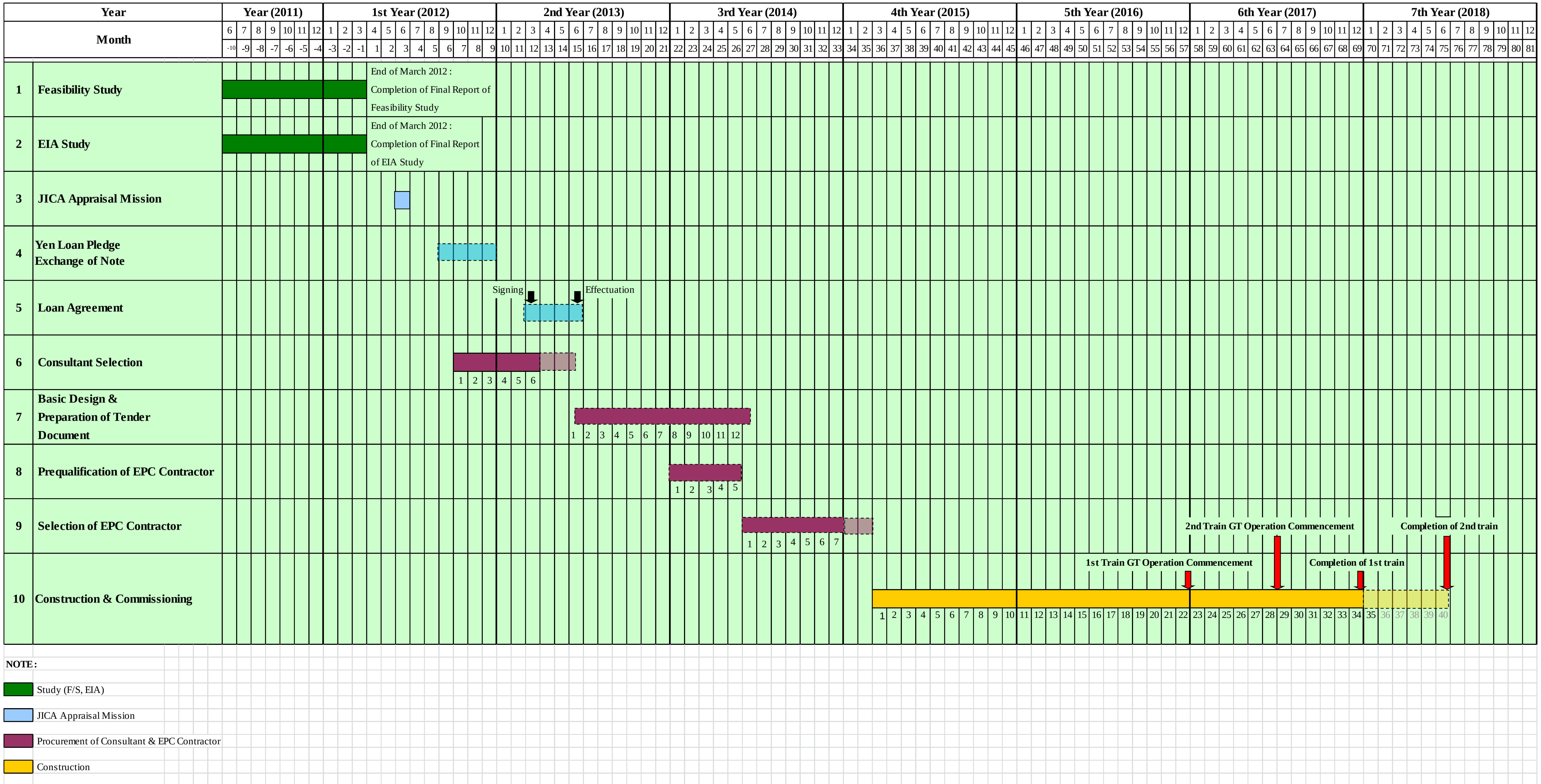
(d) EIA shall be conducted by the consultant selected by MOE, and;

(e) Project announcement is made officially by MOE and the bidding procedure will start.

In the above procedures, the Planning & Studies Office in the MOE Head Office (MOE/HQ) is responsible for developing the Project and for making decision to proceed for implementation or not. Once it is decided that Project should be implemented, then the Project Directorate (not in MOE/HQ) under Minister's Deputy for Projects is responsible for the Project afterwards such as bidding procedure.

The following schedule is expected for the period after this study completion before the Power-plant construction:

Necessary Milestones	Time Schedule Expected	
- Completion of the Final Report of the Study	March, 2012	the starting point (S/P)
- Approval of the EIA issuing the certificate:	March, 2012	the starting point (S/P)
- Dispatching of JICA Appraisal Mission	June, 2012	in 3 month from S/P
- Making of Yen-loan Pledge and Exchange of Note	December, 2012	in 9 months from S/P
- Conclusion of Yen-loan Agreement (L/A)	March, 2013	in 12 months from S/P
- Effectuation of the L/A	June, 2013	in 15 months from S/P
- Selection of Consultants for the Project Team	June, 2013	in 15 months from S/P
- Completion of Basic Design & Preparation of Tender Documents	June, 2014	in 27 months from S/P
- Prequalification of EPC Contractors	June, 2014	in 27 months from S/P
- Selection of EPC Contractors	February, 2015	in 36 months from S/P
- Commencement of EPC Activities	May, 2015	in 37 months from S/P
- Commencement of Simple-cycle Operation (1st train)	December, 2016	in 57 months from S/P
- Commencement of Simple-cycle Operation (2nd train)	June, 2017	in 63 months from S/P
- Completion of 1st Train Construction	December, 2017	in 69 months from S/P
- Completion of 2nd Train Construction	June, 2018	in 75 months from S/P



Source: Prepared by Study Team

Figure 6-1-1 Envisaged Project Schedule

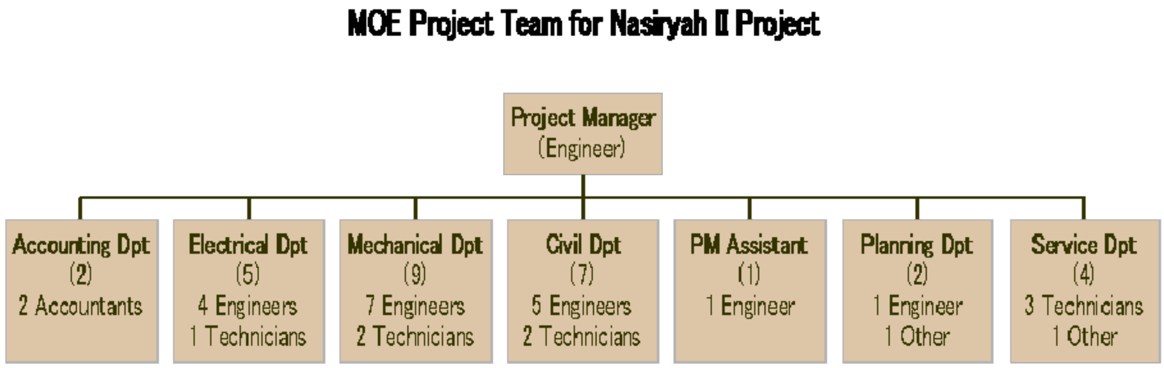
(2) Government Offices / Agencies Related to the Completion

(a) Project Team

The Project Team will be formed in the MOE as if it might be an independent department in the Regional Office under the Director General (DG) of Production Project of the Project Directorate. The Project Team is expected to be provided with the following functions:

1) To manage the power-plant construction mainly in view of the project-schedule progress and of the budget-consumption state, in the field of mechanical facilities, electrical facilities, electrical transmission, instruments and control, fuel-related facilities, water-related facilities, etc.;
2) To conserve the environment;
3) To coordinate the Project with the stakeholders in the area, and;
4) To draw up an implementation plan on supply of the power, the operation and maintenance activities in the Power Plant.

Figure 6-1-2 illustrates the project-team formation with about 30 persons at the final stage of the project construction period while its number is currently 10.



Source: MOE

Figure 6-1-2 Project-team Formation Planned at the Final Stage

Figure 6-1-3 illustrate the organization chart of the MOE. The Project Team is located just under the Minister’s Deputy for Project.

(3) Support by the Other Authorities to the Project Materialization

(a) The environmental and social consideration for the Project will be handled by the Ministry of Environment (MOEN). In view of the social consideration, the EIA have to be approved also by the Provincial Government.

(b) The ODA loan for the Project will be handled by the Ministries of Finance (MOF) and of Planning and Development Cooperation. Repayment for the ODA loan will be carried out by the Debit Management Office of MOF.

1) Resources of repayment for the ODA Loan are the budget allocated to MOE for the repayment.
2) MOE and the Power Plant have no obligation to repay the loan for MOF.

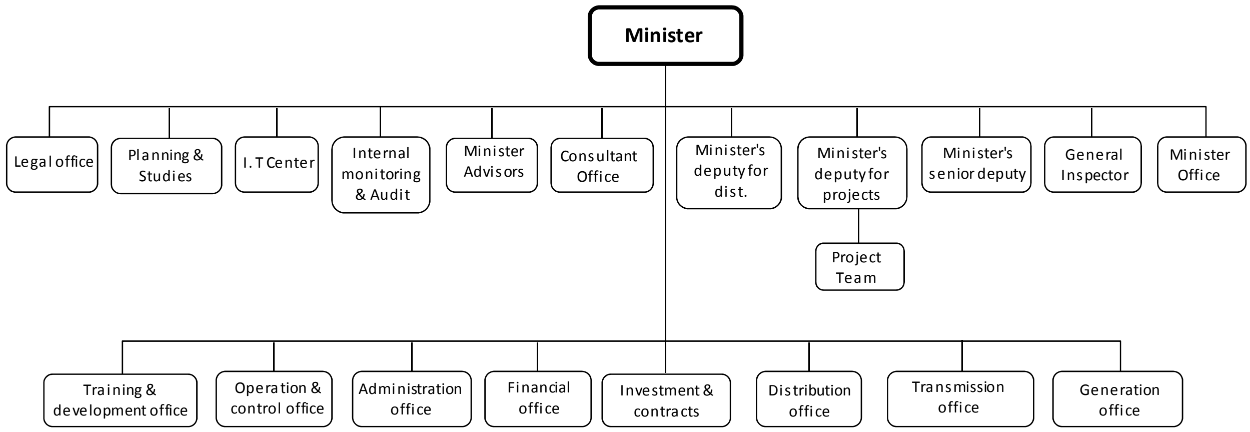


Figure 6-1-3 Organization Chart of MOE

6.2 Study of operation maintenance management

6.2.1 Concept of maintenance management

The thermal power plant is required to implement facility management with consideration given to facility reliability and efficiency maintenance even after completion of the construction. To ensure satisfactory facility maintenance management, it is required to improve the environment surrounding the facility and to configure a support system related to this environment.

Amid the drastic speed of computerization and improvement of working environment in the 1980s, there has been a growing demand for the effective operation management of the facilities in a thermal power plant. The efforts for meeting such demands have resulted in easier operation, greater power saving and improved working conditions. However, this will bring about an increase in investment funds for new facilities and maintenance management expenditures.

Computerization of the facilities contributes to improved availability and utilization factor of facilities, stabilized quality of generated power and reduced production costs. At the same time, computerization of the facilities is also intended to promote power saving, increase the degree of safety and improve the environment.

Even when there has been a great advance in the introduction of the above-mentioned computerized facilities and their operation, the major point in the operation maintenance management is found in the management of power generation facilities. The target of the management technique should cover the range from a single corrective maintenance (repair of a trouble) to improvement in the capacity factor and availability factor of the power generation facility.

The area of facility management, in the meantime, has been expanded to include an introduction plan and facility layout, and a greater importance has been attached to the management of the jigs, tools and measuring instruments for the machinery and equipment. In recent years, maintenance management designing is also studied in the phase of creating a new facility introduction plan. Consideration is being given to the selection and layout of the equipment for easier repair work subsequent to installation of the facilities, beyond conventional method of merely creating a spare parts delivery plan. However, the subsequent maintenance management is characterized by a trade-off relationship between mutually conflicting targets of higher productivity (economic efficiency in terms of servicing advantages by facility management) and lower costs for facility maintenance management.

(1) Concept of maintenance

(a) Operation performance

The operation performances can be assessed in terms of overall facility efficiency. Assessment items in a power plant include:

- Plant load factor and Availability factor
- Maintenance of performances and efficiency
- Unplanned outage ratio

(b) Definition of failure

Failure can be defined as "loss of specified functions of an item". The "item" in the sense in which it is used here refers to all the targets for reliability. To put it more specifically, the item can be classified as parts, component, apparatus, sub-system, functional unit, equipment and system. In recent years, the term "defect" is defined as "a state or place causing a failure, including an abnormality (non-conformance) found in an item".

Thus, the failure is not always clearly defined, and can be classified from various viewpoints according to the particular requirements.

- Classification according to the manner of occurrence
- Classification according to the degree of failure
- Classification according to the manner and degree of a failure
- Classification according to the impact of a failure
- Classification according to the impact of causes for a failure

(2) Operation maintenance management method

(a) Corrective maintenance

This is a conventional concept of the maintenance management where a product is repaired after having been broken. This method is adopted in many of the developing countries at present. This is the method for repairing a product after a failure has occurred. According to this method, repair work occurs sporadically and a plan cannot be easily worked out in advance. Arrangement of the personnel and procurement of the equipment and material are not efficient. However, this method is adopted when parts replacement cost on a periodic basis is very high. In this case, unplanned outage is applied in an extenuating circumstance where there is a breakdown of a boiler tube, a feedwater pump and others which constitute the major equipment playing a critical role in the heat cycle of power generation.

(b) Preventive maintenance

Preventive maintenance is based on the concept of providing maintenance to the facilities before they are subjected to a failure subsequent to their production. The preventive maintenance is intended to prevent sporadic failure and shutdown of the facilities, and provides maintenance of the facilities and their operations by replacement of parts and apparatuses at economical time intervals. The facilities are subjected to periodic inspection, repair and overhaul at prescribed time intervals of the maintenance, in conformity to the size and service life of the particular facilities. It should be noted that a plan that ignores economic efficiency (in an overall study of availability factor and maintenance cost) may be worked out, if one is too careful in the periodic inspection of the power generation facility (at intervals of one year, two years or four years) or in the preventive inspection in a typical example of the power plant.

(c) Production maintenance

Production maintenance offers the most economical method for maintenance management in terms of improving the facility productivity. This is intended to enhance the overall efficiency by reducing all costs involved in the operation maintenance related to the service life of the LCC (Life cycle cost) facilities, and by minimizing the loss resulting from deterioration of the facilities. Production maintenance is based on two concepts: One concept is intended to provide improvement maintenance where the facilities are improved in such a way as to ensure easier maintenance and repair, and to minimize the need for maintenance. Going a step further, this concept intends to improve the productivity. Another concept is intended to ensure maintenance prevention. To achieve a radical cutdown of the facility maintenance cost, this concept encourages production of the facilities that do not require maintenance, rather than making efforts for improved maintenance method. This concept puts priority to procurement. This concept is applied to procurement and improvement of the facilities wherever possible. This is the method of maintenance prevention. Adoption of this concept in the phase of designing is equivalent to application of the method of maintenance prevention.

(d) Predictive maintenance

In recent years, the concept of predictive maintenance (PM) is coming to be adopted. This concept is to determine the conditions of deterioration and status of performances of the faculties. Maintenance work is started based on this decision. To implement this concept, it is necessary to get accurate information on the condition of deterioration of the facilities. The CBM (Condition-based maintenance) is the concept of providing maintenance whenever required, based on the accurate observation of the conditions of deterioration. Due to the development of the facility diagnostic technology capable of capturing quantitative information of the status of the facilities, this technique has been converted from the time-based inspection and repair procedures to the procedures based on the information on the status of the facilities.

The above description refers to some of the concepts on the maintenance management. Basically, in the maintenance management of a power generation facility, a highly reliable operation and operation efficiency maintenance can be achieved only when a mutual support system has been established among the difference in time in terms of time axis as illustrated in the following conceptual flow diagram, and measures required for preventive maintenance and predictive maintenance. It is important that this mutual reliance should be promoted by integrated efforts on the part of the power supplier ranging from the top executives to the workers directly engaged in the practical work.

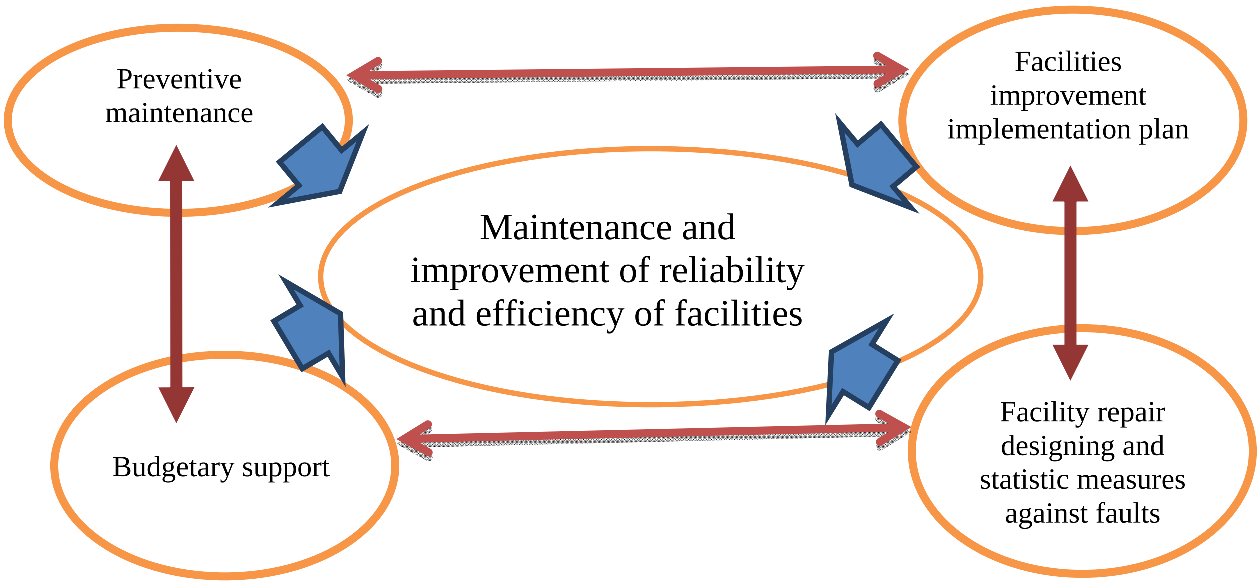


Figure 6-2-1 Maintenance management of power plant facilities

In the maintenance management for the facilities in a power plant, the crucial requirement for stable power of electricity by electricity supplier is to provide maintenance to maximize the time duration when the initial performances of the facilities at the time of purchase can be kept without being deteriorated, since the start of operation. It is equally important to continue to take interest in achieving this goal. With the establishment of a full-time division in charge of facility maintenance, there has been a functional differentiation between the facility maintenance and operation. Especially, concurrently with the modernization of the power plant (computerized operation), maintenance division and operation division have been specialized, with the result that operators are less interested in the facilities, and the slightest failure is taken care of by a maintenance specialist. This is one of the examples of the disadvantage brought about by modernization (promotion of computerization and specialization). In such a specialized system, the most important concept of improvement is going to be lost, because, inherently, the basic knowledge about the current status of the facilities should be acquired by the operator himself, and correct operation and daily maintenance work (cleaning, oiling, greasing and re-tightening) are left to the care of other divisions. In one of our efforts for the promotion of this Project, we would like to propose the optimum method for maintenance management, based on the innovation of the basic operation management method.

6.2.2 Current situation of the maintenance management for the power generation facilities in the Republic of Iraq [**&Table : Non-Disclosure]

It is difficult to clearly define in an organized manner the average working system for the power plant under the jurisdiction of the Ministry of Electricity in Iraq. Especially after the Gulf War ended in March 2003, there have been a drastic change in social system, a general confusion in the community, a mass exodus of skilled workers, followed by an increase in the number of jobless people and aggravation of the public order for four years. In conformity to the policy of the Government to reduce the number of jobless persons and to improve public order, the Ministry of Environment (MOE) is obliged to employ a great number of workers. For example, 1,000 workers are employed in a power plant. To solve the problem of overstaffing, it is important to improve the level of workmanship by unskilled workers and to implement efficient reallocation of personnel. However, more time is required to put this into practice.

(1) Power plant operation management

In a power plant such as Al-Mussaib thermal power plant which is located in the southern part of the country and is not very representative of the country, a five-group/3-shift system (eight-hour work with two holidays per week) is adopted for power generation facility operation management. The operation of the power plant is performed in the two-unit one-main control room by one group consisting of a chief shift engineer, shift operator and others. Further, the major equipment follower operators are allocated (for boiler, feedwater pump, condenser and feedwater heater). Similarly, three-shift/five-group system is adopted for the water treatment apparatus to be operated by outdoor operators. Thus, one group consists of 30 through 35 workers, and the total number of operators is 150. When the clerical workers for power plant management are included, a total of 300 persons are employed. Due to the aggravated public order in and after 2005 and the need of taking unemployment measures, safety personnel and unskilled workers were employed. Thus, one power plant is operated by 1,000 persons.

Assuming that the following current organization will be employed for the time being for power plant maintenance management subsequent to termination of this Project and the constituent number of each group for management will be adequately determined, we recommend a total of about 250 persons for the management of power plant organization.

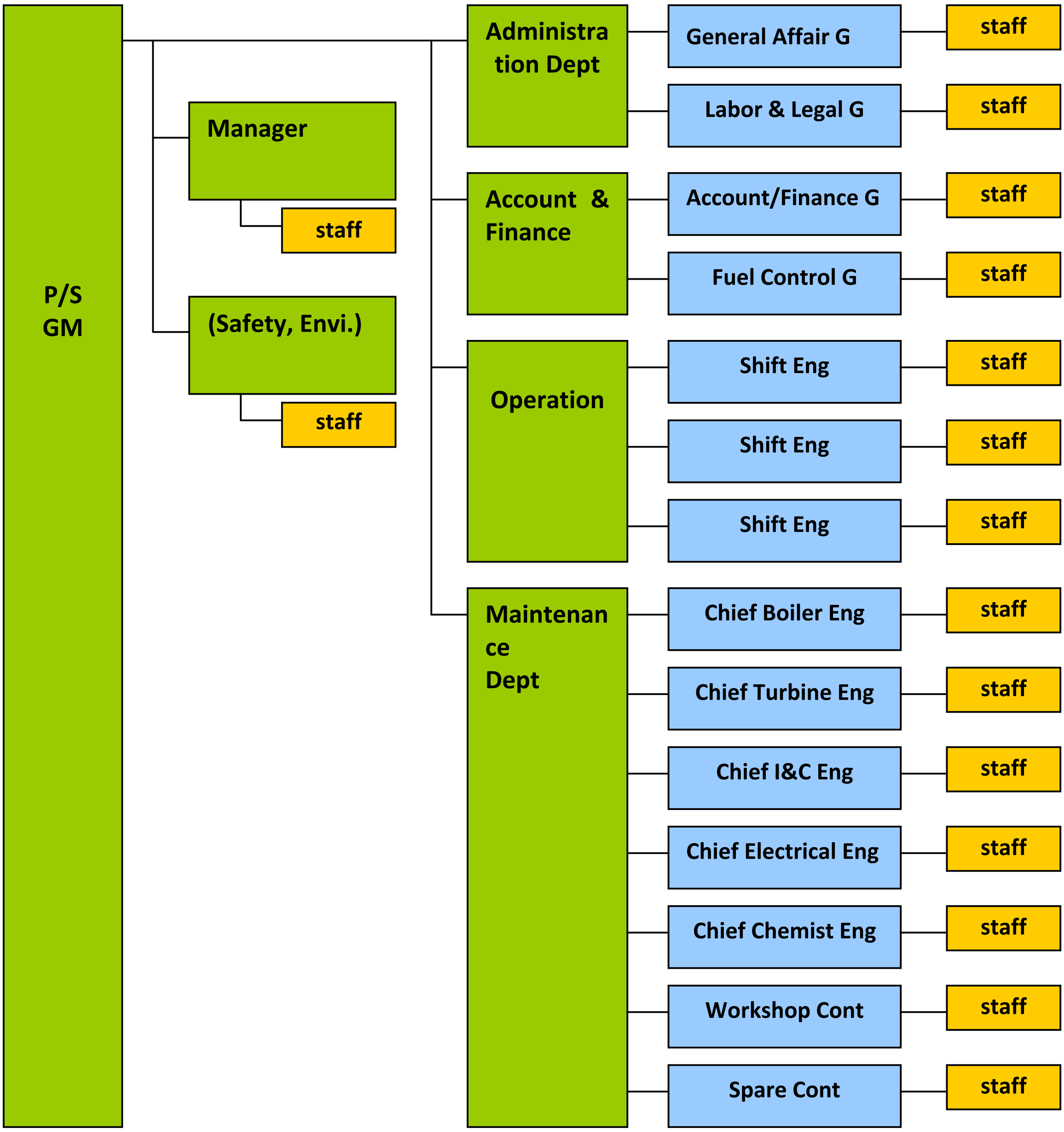


Figure 6-2-2 Current MOE power plant organization

Basically, this power plant organization system can be said to be appropriate when compared with the power plant operation management systems in other countries. If the efficient business administration and efficient operation as a future goal to be achieved are studied based on this organization system, it is necessary to implement a structural reform of the power sector including the optimization of the facility maintenance management as discussed above. This makes it necessary to overcome the current power supply crisis on a top-priority basis and to implement the structural reform of the sector. The structural reform of the sector will be discussed in the later part of this Chapter. Table 6-2-1 illustrates the O&M expenses assigned to this Project. The cost has been estimated on the assumption that the MOE will own and manage the facilities in the power plant of this Project, the expenditures for annual operation management are fixed, and variable cost is kept within the maximum possible range of repair by the MOE itself.

- The load factor is 80 % with respect to the base load.

- The operation and periodic maintenance inspection will be performed within the framework of the employment system currently adopted in the power plant under the jurisdiction of the MOE. The specialist maintenance/service personnel will be dispatched basically for periodic inspection of the major equipment components including the gas turbine, HRSG, steam turbine and generator.
- The power plant maintenance management will be basically conducted by a staff of 250.
- The wages from through *** dollars per year will be paid to the workers and specialists within the scope of MOE. If the annual average wage assumed to estimate the personnel expenditures on a permanent basis has been raised to about *,*** dollars (at a fixed exchange rate for 1998), a new combined cycle will be put to commercial operation. In this case
- The personnel expenses of the directly employed staff will cover 20 percent of the social cost.
- In the major equipment constituent maintenance and overhaul, repair work will be performed by the skilled workers of the MOE to the fullest extent feasible, based on the dispatch of an OEM instructor, using the expenditures widely spread in the advanced countries at present.
- The expenditures for maintenance material and equipment and consumables of the power generation facility will be based on the general market price.
- In the expenditures for maintenance material and equipment, and overhaul of the major equipment, the essential parts for roll-in and roll-out procedures will be supplied by the power plant. These expenditures will be leveled out and incorporated in the fixed expenditures. The variable portion will be calculated according to other load factors. Insurance cost and asset tax will be covered by a rate of 0.4 percent of the initial power plant construction cost. For the annual overall O&M, the fixed expenditures will be estimated at 5.98 $/kW/yr, and the variable expenditures will be estimated at *.** $/MWh on a tentative basis. The variable constituent element will be estimated at **,***,*** U. S. dollars.

(a) "Comment": Roll-in/roll-out repair method

The roll-in/roll-out repair method was first adopted in the Futtsu Thermal Power Plant of the Tokyo Electric Power Co., Ltd. (TEPCO) in 1984. After that, this method has been employed by the Japanese power utilities over an extensive range as a combined thermal power plant repair method. This conforms to the TEPCO maintenance policy. According to this method, a set of parts constituting the gas turbine are owned as spare parts. To minimize the inspection intervals in the periodic inspection (8,000, 24,000, 46,000 EOT time), the fuel nozzle (inspection time will be reduced if operated hydraulically). The transition portion, peripheral parts, combustion liner, turbine first stage, nozzle/bucket and turbine second nozzle/bucket are prepared in advance. The parts whose operation time has reached the EOT level at the time of inspection are entirely replaced by the parts on hand. The parts taken out will be carefully inspected. If repair is required, the relevant parts will be sent to the manufacturer for repair. These parts will be managed as spare parts to be used in the next inspection.

(b) Reference viewpoint for financial analysis

Generally, when the CCTPP is used as a basic numeral for calculation of the electric charges and others in the project development and the O&M Cost is assumed as 900 MW equivalent to *.*% (assumed as *** million per block in this Project) of the construction cost, about **,***,*** dollars can be calculated as an annual cost.

Table 6-2-1 O&M expenditures

[Non-Disclosure]

Table 6-2-2 Fixed cost and variable O&M cost

[Non-Disclosure]

(2) Overview of gas turbine long-term maintenance policy after commencement of commercial operation

(a) Corrective maintenance

- The major facilities of the combined cycle power generation facility include a gas turbine, HRSG and steam turbine. Generally, of these major facilities, the gas turbine is characterized by the greatest failure rate. The maintenance of the gas turbine has a serious impact on the overall availability factor of the plant. The combustor and turbine blade as high-temperature parts of the gas turbine are exposed to a high-temperature gas of 1,000°C or more during the operation. This means more serious deterioration and damage as compared to the blade of the steam turbine. Inspection, repair and replacement are required in a shorter period of time. Thus, these high-temperature parts have their expected service life set for each type by the manufacturer, the user is required to conduct inspection, repair and replacement at prescribed maintenance intervals until the service life expires. The gas turbine inspection intervals may differ to some extend in conformity to each manufacturer. Generally, inspection is carried out for each of the following three types in recent years. Due to the technological development and improvement of the material used for the gas turbine, the combustor inspection interval of 8,000 has come to be extended. For example, GE has changed the EOT concept to allow the extension of the inspection intervals. Similarly, MHI (Mitsubishi Heavy Industries, Ltd.) and Siemens allow the inspection intervals to be extended.
- the long-term maintenance management service is equal to or less than the overall costs of inspection,
- repair and replacement performed by the user. When the supplementary services are taken into account, this is an attractive proposal. These costs are determined when the agreement is signed. This enables the user to avoid unexpected risk of having to repair or replace the high-temperature parts. Further, when the user separately performs repair and replacement of the high-temperature parts, there will be a great variation in cost burden between the year when replacement of a large amount of high-temperature parts is required and the year when no replacement is needed (about **,***,*** dollars for one F-type gas turbine). For the user such as IPP where the company size is smaller, this will have a serious impact on the company business administration. When management is conducted by the power plant, there will be a serious impact on the operation time when consideration is given to impact on the high-temperature parts due to operation shutdown or emergency shutdown during the actual operation. Further, operation may be continued in excess
- of the time of inspection to be conducted at the convenience of the power plant, in some cases. Thus, unwanted repair may have to be performed. In sharp contrast, in the long-term maintenance service system, the cost burden can be leveled out by paying a fixed amount per month. Based on this situation and various conditions in Iraq, this Project proposes long-term maintenance management
- systems which are illustrated in the following brief comparison table. As part of the efforts for improving overall efficiency of the MOE, introduction of this service will pave the way for the future structural reform of the power sector including stabilized operation of the power plant and adequate allocation of personnel.

Inspection intervals according to type (example)

Combustor Inspection	8,000 hr
Turbine Inspection	16,000 hr
Major Inspection	48,000 hr

The high-temperature parts of the gas turbine are made of nickel- and cobalt-based superalloy. The repair requires an advanced level of special welding and coating technique and facilities. Thus, a lot of time is required in acquiring the level of skill, and the power plant is required to keep skill workers and facilities. This may lead to a very inefficient reallocation of personnel. From the viewpoint of business administration efficiency, gas turbine manufacturers and expert repair companies are commissioned to perform repair work. As described above, the high-temperature parts are subjected to periodic inspection, repair and replacement which are conducted in reduced time intervals. Thus, a collective maintenance agreement (long-term maintenance management policy) for a specified time period has been proposed by gas turbine manufacturers including GE. This is coming to be a standard agreement in the operation of the CCTPP (Combined Cycle Thermal Power Plant). The agreement period is normally six or twelve years since the process up to the major inspection is considered as one cycle. The following table summarizes the features of the long-term maintenance management service. In the first place, the technological features can be described as follows: In the conventional method, the user acquires information on the operation time, the number of operation starts and stops, and the number of emergency shutdowns, and has been engaged in the management to determine the scope and intervals for inspection, repair and replacement of the high-temperature parts. It is important the point to keep in the mind as the long –term management guidance anticipates check, repair, the exchange expense of the high in the long term, and to secure a budget. On the other hand in the long-term maintenance management, this management is conducted by the service provider. This method will ensure dispatch of stationed engineers, monitoring of a trouble symptom and quick response to a trouble, with the result that the availability factor can be improved. Another conspicuous feature is that high-temperature parts inspection, repair and replacement costs are included in a package price. It is thought about a contract (long term maintenance management service) to provide it by lump for the fixed period of time that there is shifting to a maintenance method provided by each gas turbine manufactures to occur at the interval when MOE relatively have a short periodical check, repair exchange of the high temperature part when a maintenance regime mature in the future and, besides sector reform advances with the expansion of the Iraq electricity sector-scale and management efficiency in the electricity sector including the privatization of the power generation sector comes to be demanded.

The following illustrates the comparison of the features of the long-term maintenance management service.

Table 6-2-3 Features of the Long-term maintenance management service

	Long-term maintenance management agreement	Separate ordering
Inspection, repair and replacement management for high-temperature parts	Package management by provider	Management by user
Monitoring of gas turbine operation status	Contribution to improvement of remote monitoring availability factor also on the part of the provider	Monitoring by user alone
Engineer	Stationed	Not stationed
Availability factor	Assured (optional)	Not assured
Costs of inspection, repair and replacement management for high-temperature parts, and payment	Monthly payment of a fixed amount at a package price. The price is equal to or less than the total cost at the time of separate ordering. The cost of unexpected repairs or replacements is paid by the provider (except when the user is responsible).	For each inspection, the amount corresponding to the repair and replacement is paid. The cost of unexpected repairs or replacements is paid by the user.

The following shows an example of the list (250 MW × 2:750 MW combined cycle) required for inspection of one cycle (approximately 5 or 6 years) of the gas turbine illustrated in Table 6-2-4. When these spare parts are prepared, it will be possible to ensure efficient management of the inspection in the combined cycle power plant or recovery of the gas turbine from an unexpected accident. The reliability can be maintained and the availability factor can be improved.

Table 6-2-4 Spare parts list for gas turbine (roll-in/roll-out maintenance)

Description	Q'ty recommended in Spare Parts "B"				'CATEGORY-1'				'CATEGORY-2'				'CATEGORY-3'			
Fuel Nozzle	2	sets	40	pcs	2	sets	40	pcs								
Transition piece assembly (Combustor baskets)	2	sets	40	pcs	2	sets	40	pcs								
Combustion Liners (Transition piece)	2	sets	40	pcs	2	sets	40	pcs								
Turbine first stage nozzles (Row 1 vanes)	2	sets	80	pcs	1	set	40	pcs	1	set	40	pcs				
Turbine first stage buckets (Row 1 blade)	2	sets	192	pcs	1	set	96	pcs	1	set	96	pcs				
Turbine second stage nozzles (Row 2 vanes)	1	set	32	pcs	1	set	32	pcs					1	set	32	pcs
Turbine second stage buckets (Row 2 blade)	1	set	87	pcs	1	set	87	pcs					1	set	87	pcs
Turbine third stage nozzles (Row 3 vanes)	1	set	18	seg	0.5	set	9	seg	0.5	Set	9	seg				
Turbine third stage buckets (Row 3 blade)	1	set	112	pcs	0.5	set	56	pcs	0.5	Set	56	pcs				
Row 1 ring segment													2	Sets	120	pcs
Row 2 ring segment													2	sets	128	pcs
Spark plug assembly	2	sets	4	pcs	1	set	2	pcs	1	set	2	pcs				
Ultraviolet flame detector assembly	2	sets	8	pcs	1	set	4	pcs	1	set	4	pcs				
Thermocouple, exhaust and trip	2	sets	52	pcs	1	set	26	pcs	1	set	26	pcs				
Each type of journal bearing pads	1	set	2	pcs	1	set	2	pcs								
Thrust bearing pads	1	set	1	pcs	1	set	1	pcs								

6.2.3 Goal to be achieved by MOE

(1) Structural reform of the power sector

It is necessary to illustrate the ideal image of the power sector as they ought to be in future when this Project is implemented. Especially during the period from 2015 through 2018, a great number of gas turbines will be laid out in parallel on the system. The gas turbines to be placed in parallel will be converted into a combined cycle. When the MOE as a national agency is to work out a plan of installing new facilities and to take charge of the management in the maintenance of the existing power generation facilities, the MOE will be required to take correct steps in various aspects in the distribution of the national budget and efficient management. The MOE as an agent responsible for power supply is required to reconsider the reason for the need of implementing the structural reform in terms of "characteristics of the electricity as an asset" and "mission of electric industry".

(a) Characteristics of the electricity as an asset

- Electricity has inherent characteristics that cannot be found in other assets. Electricity requires the supply-demand balance to be kept at all times. For example, the electric industry and telecommunications industry belong to the same network industry. However, when the demand has been increased close to the limit of the supply capacity, "The line is busy" will occur and communications will be disabled in the telecommunications industry. When the supply-demand balance has been recovered, communications are resumed. However, electricity cannot be stored. This requires the supply-demand balance to be kept at every moment. If the demand/supply balance cannot be maintained, blackout may occur over an extensive range.
- If the required supply cannot be ensured and supply-demand balance cannot be maintained due to a failure in the design of the business model, the people's living and economic activities will be exposed to a serious impact.
- Electricity cannot be easily replaced by other alternative, and the demand is less elastic, although electricity is essential to people's lives and economic activities.
- Much time is required to construct the facilities and shortage of electricity cannot be covered immediately. To put it another way, the supply of electricity is less elastic.

(b) Mission of electric industry

- The mission of the electric industry is to supply electricity at a stable and reduced price.
- To achieve this mission, compatibility between the public requirements (ensuring the energy security and environment for maintaining the supply reliability) and efficiency is indispensable.
- Efforts should be made to promote efficiency in business administration and to form the facilities for power source distribution as an integral unit from the long-term viewpoint, thereby meeting the public requirements through the operation.

Because of the characteristics of electricity as an asset, the national agency as an electricity supplier is faced with difficult management problems in meeting the public requirements, when consideration is given to such a basic item as mission of the electric industry. Looking back on the transition of electric industrial regime in Japan, state control management was enforced in the 1940s and an overall policy of reduced and uniform low-electric power rate was adopted throughout Japan, with the result that the Government subsidy had to be granted. Further, the location and scope of responsibility for power supply and distribution became less clear for the Government. This resulted in frequent blackout and deterioration in services. Based on the experience learnt from these problems, Japan was divided into nine areas in the 1950s, and private companies voluntarily took responsibility for power supply in a system covering both power transmission and distribution in an integrated manner, thereby ensuring stable power supply to all parts of the country. As a result, the supply of electricity as a major segment of the social infrastructure was successfully separated from the management by the national agency. These private companies were responsible for voluntary business administration and operation in the supply of electricity, so that demand/supply balance for each region could be achieved at an earlier date. This has successfully encouraged development and improvement of power supply in each region, and made a significant contribution to the development of the Japanese economy thereafter. As described above, when the power supply structure has grown in size, it is essential for Iraq to minimize the impact of the Government and to design a system capable of improving the electricity infrastructure through quick decision-making step.

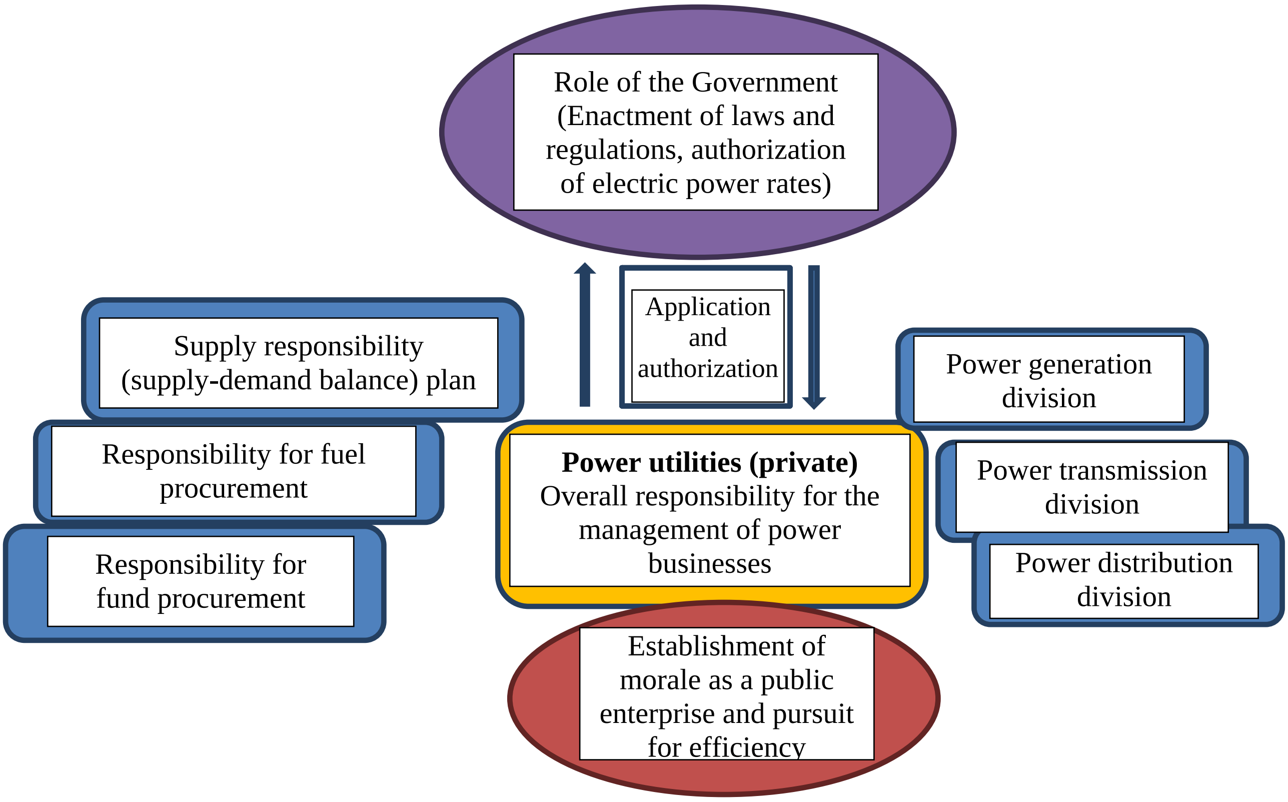


Figure 6-2-3 Conceptual diagram of Japanese electric power businesses

6.2.4 Factors of electric power crisis in Iraq

(1) Understanding the current situation of the power facilities in Iraq

The Iraqi power supply system was improved and reinforced gradually, and the overall installed power generation capacity reached a level of 9,300 MW just before the Gulf War of 1991. However, approximately 70 percent was destroyed in the Gulf War, with the result that the currently available capacity is greatly reduced to 2,320 MW. In the face of this situation, the following analyzes the current situation of chronic shortage of power supply relative to power demand due to the delay in recovery caused by insufficiency of the material and equipment, as well as the delay in the recovery of power supply, based on the recently available data.

(a) Power facilities

1) Thermal power generation facilities

The following table illustrates the generation capacity of the thermal power generation facilities (design value) and actually available power generation capacity, as of May 2010.

Table 6-2-5 Design output vs. Actual output thermal power plant (May 2010)

	Name of power plant	Number of facilities and capacity	Overall output (design value MW)	Actual output (MW)
1	Beji	220MWX6	1320	250
2	Bagdad South	55MWX4	220	80
3	Dore	160MWx4	640	250
4	Mussaib	300MWX4	1200	750
5	Nassriah	210MWX4	840	520
6	Harth	200MWX4	800	360
7	Najebiyah	100MWX2	200	120
	Total		5220	2330

Source: Electricity Statistics of Iraq

2) Gas turbine power generation facilities

This is a summary of the gas turbine power generation facilities across Iraq, as of May 2010.

Table 6-2-6 Summary of GT power generation facilities in Iraq (May 2010)

	Name of power plant	Number of facilities and capacity	Overall output (design value MW)	Actual output (MW)
1	Mousel13	13	273.6	135
2	East Mousel Mobile 5	5	55	-
3	Ar bel	4	492	430
4	Sulaimaiyah	4	492	430
5	Debis 3	3	112.5	85
6	Debis Mobile 5	4	40	-
7	Old mulla 12	12	240	65
8	New Mulla 6	6	222	75
9	Kirkuk	1+1	325	285
10	Beji 4	4	636	320
11	Beji Mobile 8	8	161	-
12	South Baghdad 2	18	400	360
13	South Baghdad New	2	246	185
14	Al Dura 4	4	150	120
15	Al Qudus 10	6+4	910	560
16	Al Taji 7	7	160.4	100
17	Al Hilla 8	8	165	80
18	Al Mussaib 10	10	500	270
19	Al Najaf 3	3	189	60
20	Al Najaf New	2	246	185
21	Samawah 1	1	43	30
22	Nasriyeh	1	43	25
23	Buzergan	1	43	35
24	Khour Zubair 6	4+2	498	235
25	Al Ptro 4	4	80	20
26	Suaiba 4	2+2	66	30
	Total		6,788.5	4,120.0

Source: Electricity Statistics of Iraq

3) Hydraulic power generation facilities

The following table illustrates the generation capacity of the hydraulic power generation facilities (design value) and actually available power generation capacity, as of May 2010.

Table 6-2-7 Design output vs. Actual output hydro power plant (May 2010)

	Name of power plant	Number of facilities and capacity	Overall output (design value MW)	Actual output (MW)
1	Samarra	3	84	44
2	Himrin	2	50	12
3	Hadytha	6	660	40
4	Hindya	4	15	4
5	Kufa	4	5	0
6	Dokh	5	400	145
7	Drbh	3	249	80
8	Mousel Dam M	4	750	258
9	Mousel Dam R	4	60	40
10	Mousel Dam p	2	240	115
	Total		2513	738

Source: Electricity Statistics of Iraq

4) Diesel power generation facility

The following table illustrates the summary of the Diesel power generation facilities across Iraq.

Table 6-2-8 Design output vs. Actual output diesel power plant (May 2010)

Name of power plant	Number of facilities and capacity	Overall output (design value MW)	Actual output (MW)
Samawa D	4	60	20
Samara D	20	340	190
North Baghdad	4	45	36
Support D		500	0
Total		945	246

Source: Electricity Statistics of Iraq

In the above description, the power generation facilities are classified according to categories, and the overall generation capacity of all the facilities across Iraq and the possible output (supply) capacity are illustrated.

5) Summary of power generation facilities

The following Table summarizes the overall generation capacity of the power generation facilities across Iraq and the possible supply capacity, as of May 2010.

The overall installed generation capacity is equivalent to 15,500 MW. However, the entire facilities are dilapidated. Due to the difficulties in repair maintenance resulting from insufficiency of the required material and equipment after the Gulf War of 1991, the possible supply capacity is less than 50 % of the overall design output value, even as of May 2010.

Table 6-2-9 Design output vs. Actual output overall power plant (May 2010)

	Name of power plant	Number of facilities and capacity	Overall output (design value MW)	Actual output (MW)
1	Thermal power generation facilities	28	5220	2330
2	Gas turbine power plant	146	6788.5	4120
3	Diesel power generation facilities	28	945	246
4	Hydraulic power generation facilities	37	2513	738
	Total		15,466.5	7,434.00

Source: Electricity Statistics of Iraq

(b) Reinforcement of power generation facilities

Since lifting of sanctions against Iraq was determined in the United Nations Security Council after the Iraq War in 2003, the Iraq Rehabilitation Program was worked out and the Iraqi social infrastructure rehabilitation program including the grant aid was started. Efforts have been made to reinforce the power generation facilities. After 2003, power generation facilities have been reinforced. Many small-sized power generation facilities of gas turbine type have been newly constructed since this type is characterized by shorter construction period. However, due to a shortage of the budget for purchasing the equipment and spare parts, troubles have occurred in the maintenance management. Newly built facilities have been faced with the problem of reduced generator capacity.

Table 6-2-10 Reinforcement of power generation facilities after Iraqi War

		Name of power plant	Reinforced power (MW)	
	Gas turbine power plant	Arbeel	500	
		Sulaimanyh	500	
		Kirkuk	325	
		Baghdad South 2	400	
		Baghdad South 1	250	
		Qudus	250	
		Mussaib	500	
		Najafn	250	
		Samawa	43	
		Nasyriah	43	
		Bezorugan	43	
		Khour Zubair	250	
	Total		3,354	
	Diesel power generation facilities	Samawa Samara North Baghdad	60 340 45	
	Total		445	
	Power interchange	Hemirin KhourZubair Diala Turkey Barejat	140 190 360 160 45	
	Total		895	
	Total		4,694	

The installed capacity is increased up to 15,500 MW from the overall design output of 11,667 MW in 2004 according to the support program after 2003, as illustrated in the summary of (d). An increased output of 3,833MW was registered.

(c) Power demand

The major power generation facilities were destroyed in the Gulf War of 1991, and the boilers were bombarded in two units of the Hartha thermal power plant (delivered by Mitsubishi Heavy Industries, Ltd.: 200 MW × 4 units). At present only two units are being operated. Under this circumstance, the latent demand was estimated to be more than 6,000 MW (6 MKW) as against the power generation capacity of about 4,000 MW in 2003. The following shows the transition of the latent demands and the transition of supply capacities:

Table 6-2-11 Transition of the latent demands and the transition of supply capacities

Year	Max. supply capacity（MW）	Estimated latent demand（MW）
2004	5,336.0	7,372.0
2005	5,389.0	8,845.0
2006	5,383.0	9,896.0
2007	5,530.0	10,768.0
2008	6,240.0	11,528.0
2009	7,575.0	12,269.0
2010	8,085.0	13,453.0

Note: The data after 2008 includes the power supplied by power interchange agreement with the Kurdish region, Syria, Turkey and Iran.

Since the power generation facilities were damaged in the 1991 Gulf War, the power supply capacity in Iraq remained at a level of 4,000 MW without being increased, up to the 2003 Iraq War. The power supply for the period of about twelve years was 3,500 MW, which was supplied to Baghdad and the surrounding area. Extremely limited amount of power was supplied to local districts. Further, in Baghdad, power was supplied on condition of blackout on a rotating basis, with the exception of the Government agency offices and high-ranking ministerial residences.

At present, as can be seen from the above table, there is a serious gap between the latent demand and generation capacity. Further, power is supplied only for three or four hours a day in some districts.

As described above, about ten years have passed since the end of the 2003 Iraq War. However, power crisis problem cannot be solved for the following reasons:

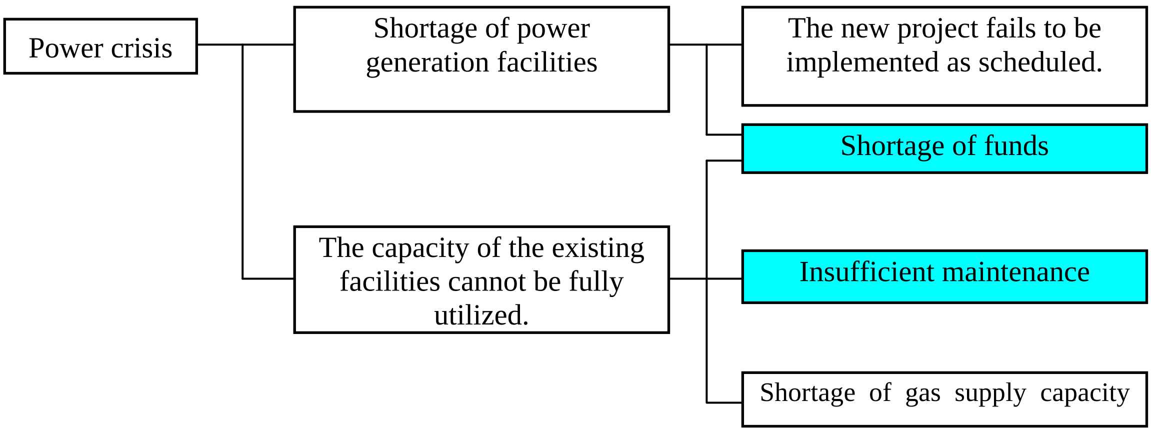


Figure 6-2-4 Power crisis problem can not be solved for the reason

In an effort to solve the problem of power crisis, the MOE as a member of the Iraqi power sector is required to take part in solving the problem. When viewed from this aspect, of various factors causing the current power crisis, the "shortage of funds" and "insufficient maintenance" are the factors that can be solved by the MOE.

6.2.5 Ideal image as ought to be, subsequent to structural reform of the sector

To solve the current problem, it is necessary to carry out efficient business administration and to develop human resources within the company. As shown in the following table, in the power sector of this country, there are few companies having succeeded in both the independent business administration and development of human resources indispensable to the efficient business administration. The goal to be achieved by new companies is to achieve success in both the independent business administration and development of human resources indispensable to the efficient business administration, to ensure development of the companies on a continuous basis.

(1) Goal to be achieved by MOE (vision)

The goal to be achieved by MOE (vision) is required to conform to the "road map for implementing the structural reform of power sector". Regarding the road map for implementing the structural reform of power sector, the following shows the items related to power generation:

Road map for implementing the structural reform of power sector (2015-2020)

Reform of the existing power plant

1.1 All the existing power plants in the public sector should be converted into profit centers, which should be integrated into several corporations in the final phase.

1.2 The business management and financial planning should be worked out.

1.3 The Government (MOE) should be responsible for the structural reform of power sector, and new businesses should be managed on a commercial basis.

1.4 Technological level should be upgraded and management efficiency should be enhanced. A management plan should be worked out in an effort to establish the optimum governance.

1.5 Particular care should be taken in working out a human resource development program.

1.6 Quality management activities should be introduced to upgrade technological level and management capacity, and to establish an accountability framework.

A new power plant

The optimum governance, effective O&M and commercial environment should be established in the power plant of the public sector.

(2) Vision after establishment of a power utility company

In the business administration organization, the business administration vision of a new utility company should be clearly defined, and should be notified to all the staff members of the organization. The following illustrates the vision of the utility company formulated on the basis of discussion with the major interested parties of the new utility company:

The new utility company should have the vision for the business administration, which can be represented by the following three major elements: "independent business administration", "highly reliable power supply" and "continuous development". The goal is a balanced achievement of such major elements. The following illustrates the business administration vision:

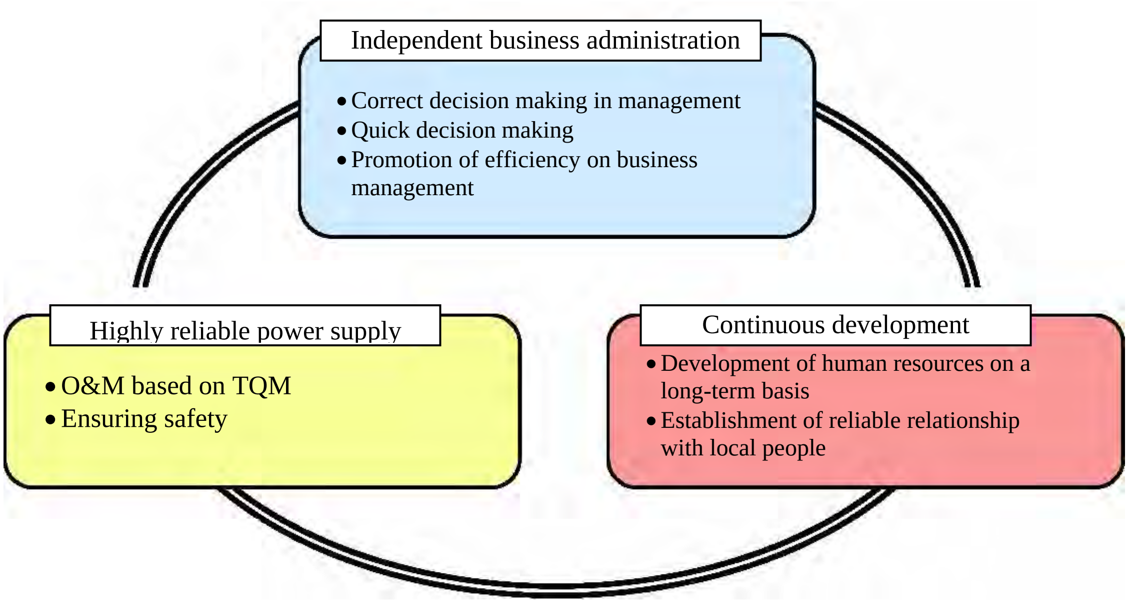


Figure 6-2-5 Image of business administration vision

(a) Individual business administration

To realize the independent business administration, business executives are required to make correct decision on business administration and to perform quick decision making. For this purpose, the business executives and their entourages should be composed of the distinguished personnel of great initiative, and it is important to create a system which provides accurate information whenever required. Further, to ensure required investment to be made whenever required, it is necessary to achieve earlier establishment of a framework capable of ensuring the income and expenditure balance.

(b) Highly reliable power supply

Reliability of power supply in Iraq is not very high. The absolute number of the power generation facilities is insufficient. This is the greatest cause for poor reliability. Another cause is lack of awareness of this problem among the personnel working in the power sector. In a new utility company, each person is required to be determined to achieve highly reliable power supply. It is important to create a framework of implementing an O&M based on the performance data and facts using the TQM. Further, it is necessary to make an arrangement to ensure that a sufficient care can be used to protect safety of the facilities as well as personal safety, thereby preventing an accident from occurring.

(c) Continued development

When a power utility company wishes to implement continued development, it is indispensable to train and develop in-house maintenance personnel from a long-term viewpoint so that minor maintenance can be performed independently. Further, a new utility company should make efforts to employ local people so as to establish a reliable relationship with the local community.

6.3 Financial/Economic Analysis

6.3.1 Assumptions and Conditions in Financial/Economic Analysis [Non-Disclosure]

[Non-Disclosure]

6.3.2 Performance effect indexes of power plant facilities

In the power generation facilities, main equipment and its auxiliaries are designed to avoid usually have any problem in use through durability period. In addition, auxiliaries of power plant are also be designed to keep the long term for achieving high availability. The power plant facilities of main equipment and auxiliaries introduce and built up to obtain high efficiency and reliability based on the latest technology.

In relation with the above design concept on the new power generation facility, the target of the management technique should be provided to improvement in the capacity factor and availability factor to be used as an operative effect index based on the operative period when recruit Part 9 according to an index defined with "reliability, availability, conservatism, safety" and established below it of the 1999(E) "gas turbine - procurement", and a main of power generation facilities with auxiliaries are applied continuously while keeping high effectiveness and reliability and superior economy during an operative durability period, and the element of annual average availability suggests ISO 3977-9 for an index of the maintenances. It is necessary to carry out performing the maintenance of the power generation facilities routinely in the power generation based on this index.

(1) Definite items to be used for the operative effect management index

As for the evaluation as the index through during the durability period of the power plant facilities, it should be established to appear as a result of good maintenance, the following items become the big pillar as overall equipment efficiency.

- Plant load factor and availability
- Maintaining of plant performance and efficiency
- Rate of the unplanned outage

Table 6-3-8 shows detail management index for evaluating plant condition after commencement plant operation.

Table 6-3-8 Operative Effect Index

Index name	Index method	The management targeted value	Purpose	Remarks
Max power Out put (MW)	At Generator end	835MW	Maintenance index	Power station site climatic condition (30 degrees C) Big pillar of the maintenance index
Plant load Factor (%)	= Annual generation quantities/ Rating output x Annual calendar hours x100	80% - 85%	Maintenance of the plan level	The power plant is designed on the a base load plant and assume around 85% a management index after a commencement from these relations for five years.
Availability Factor (%)	= annual operation time / annual calendar hours x100	80% - 90%		Index evaluating value will slightly be cahnged depending on the scales of the periodic inspection.
Power plant efficiency (%)	= (annual generation quantity at generation end x860)/ (annual fuel consumption x fuel calorific value) x100	56% - 57%	Management index (performance confirmation) of the maintenance	Aging ratio of the gas turbine shall be considered, but it is desirable to make an effort to maintain this efficiency basically during the durability period of power plant.
House power Rate (%)	=Annual house power consumption / annual generation quantity at generator end x100	3.5% - 4%		Aging ratio of the power plant auxiliary facilities shall be considered, this efficiency basically maintained during the durability period of power plant.
Unplanned outage and planned outage	The total of the outage time for the power generation facilities ● The human error ● Malfunction of facilities ● For preventive maintenance		Data collects as a basic statistical document for effect promotion of the maintenances	

The performance test for conforming of index of operative effect for the power plant facilities shall be carried out periodically, and the comparison with the index management level shall be conducted and analyzed for the indicating values the above based on the performance test of the power generation facilities for gas turbine burner (12,000hours) inspection, 24,000,hours inspection, 48,000hours inspection, the inspection of other steam turbines in total or regularly (as for every one year), and analyzed results, it is desirable as possible for a next inspection plan to particularly devote to restrain the output, efficiency, a decline of the availability as much as possible.