CHAPTER 5 EXISTING AND COMMITTED PROJECTS

5.1 Generating Plant

5.1.1 Existing Projects

To satisfy Iraq's peak electricity demand during the summer in 2004 (assumed in August), rehabilitation, repair, additional installation and programmed maintenance work for the existing power plants have been preceded. According to our survey, based on information from the Ministry of Electricity and CPA, the status of the existing power generating plants, which are expected to meet peak demand of the 2004 summer, are described in the following tables.

Table-5.1-1 Status of Existing Power Generation Plants - Steam Turbine Plant

Ref.No	Name of Plant	No, of Installed Unit	No.of Operable Unit	Unit Installed Capacity(MW) / Unit Maximum Operable Capacity(MW)						Total Installed Capacity (MW)	Total Maximum Operable Capacity (MW) *1	Type of Fuel *2	Remarks
				1	2	3	4	5	6				
T-1	Dibis TPS	4		15	15	15	15			60			
			4	5	10	10	10				35	NG	
T-2	Baji TPS	6		220	220	220	220	220	220	1,320			
			5	100	100	100	100	0	100		500	FO	
T-3	Doura TPS	4		Rtd	Rtd	160	160	160	160	640			
			4			100	100	130	130		460	FO	
T-4	Baghdad South TPS	6		55	55	55	55	67.5	67.5	355			
			6	35	35	35	30	30	30		195	FO	
T-5	Musayab TPS	4		300	300	300	300			1,200			
			4	210	200	220	230				860	CO/FO	
T-6	Nasiriyah TPS	4		210	210	210	210			840			
			4	130	180	160	130				600	CO	
T-7	Najibiyah TPS	2		Rtd	Rtd	Rtd	Rtd	100	100	200			
			2					80	80		160	NG/CO	
T-8	Hartha TPS	4		200	200	200	200			800			
			2	175	0	0	175				350	NG/CO	
	Total	**34**	**32**							**5,415**	**3,160**		

🟪	More than 30 years operation (commissioned before 1974)
🟧	More than 20 years operation (commissioned before 1984)
🟨	More than 10 years operation (commissioned before 1994)
🟦	Rehabilitated/installed by 2003
🟦	Rehabilitation/Repair is underway.
Rtd	Retired Unit due to old age/accident
☐	Not exist or no definitive plan known.
0	Status is unknown.

NB) *1 Based on Needs Assessment Reports in 2003 and CPA Home Page (essential service)

*2 Fuel type reported by CPA in May 2003 and subject to change

Type of Fuel

NG ::	Natural gas
CO :	Crude Oil
GO :	Gas Oil
FO :	Fuel Oil

Table-5.1-2 Status of Existing Power Generation Plants - Gas Turbine Plant

Ref.No	Name of Plant	No, of Installed Unit .	No.of Operable Unit	Unit Installed Capacity(MW) / Unit Maximum Operable Capacity(MW)												Total Installed Capacity (MW)	Total Maximum Operable Capacity (MW) *1	Total Available Capacity derated by Ambient Temterature (MW)*2	Type of Fuel *3	Remarks
				1	2	3	4	5	6	7	8	9	10	11	12					
G-1	Mosul GPS	12		🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	240				
			12	🟩 16	🟧 18	🟩 16	🟧 18	🟧 18	🟧 18	🟧 18	🟧 16	🟧 18	🟧 18	🟧 18	🟧 18		210	150	NG	
G-2	Dibis GPS	3		Rtd	Rtd	Rtd	🟧 28	🟧 28	🟧 28							84				
			3				🟩 23	🟩 23	🟩 23								69	59	NG	
G-3	Dibis Mobile GPS	5		🟧 10	🟧 10	🟧 10	🟧 10	🟧 10								50				
			5	🟧 8	🟧 8	🟧 8	🟧 8	🟧 8									40	33	NG	
G-4	Mullah Abdulla(Old) GPS	12		🟦 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	240				
			12	🟦 15	🟦 15	🟧 15	🟧 15	🟧 15	🟧 15	🟦 15	🟧 15	🟧 15	🟧 15	🟧 15	🟦 15		180	150	NG	
G-5	Mullah Abdulla(New) GPS	6		🟨 37	🟨 37	🟨 37	🟨 37	🟨 37	🟦 37							222				
			6	🟩 30	🟩 30	🟩 30	🟩 30	🟩 30	🟦 30								180	150	NG	
G-6	Baji GPS	2		🟩 159	🟩 159											318				
			2	🟩 125	🟩 125												250	210	CO/GO	
G-8	Taji GPS	7		🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20	🟧 20						140				
			7	🟧 10	🟧 10	🟧 17	🟧 17	🟩 15	🟧 15	🟧 16							100	80	NG	
G-9	Taji Mobile GPS	6		🟧 10	🟧 10	🟧 10	🟧 10	🟧 10	🟧 10							60				
			2	🟦 10	🟦 10	0	0	0	0								20	17	GO	
G-10	Doura GPS	4		🟧 25	🟧 25	🟧 25	🟧 25									100				
			4	🟩 15	🟩 15	🟧 15	🟩 15										60	40	NG	
G-11	Al-Quds GPS	2		🟩 123	🟩 123											246				
			2	🟩 100	🟩 100												200	160	CO/GO	
G-12	Hilla GPS	3		🟥 20	🟥 20	🟥 20	🟥 20									80				
			3	🟥 18	🟩 18	🟥 18	🟥 18										72	64	NG	
G-13	Najaf GPS	3		🟧 63	🟧 63	🟧 63										189				
			3	🟧 30	🟦 52	🟧 50											132	110	NG	
G-14	Khor Alzuber GPS	4		🟧 63	🟧 63	🟧 63	🟧 63									252				
			4	🟩 50	🟦 52	🟩 50	🟦 52										204	180	NG	
G-15	Shuaiyba GPS	2		🟥 20	🟥 20											40				
			2	🟥 12	🟥 12												24	20	NG	
	Total	**71**	**67**													**2,261**	**1,741**	**1,423**		

🟥 More than 30 years operation (commissioned before 1974)
🟧 More than 20 years operation (commissioned before 1984)
🟨 More than 10 years operation (commissioned before 1994)
🟩 Rehabilitated/installed by 2003
🟦 Rehabilitation/Repair is underway.
Rtd Retired Unit due to old age/accident
☐ Not exist or no definitive plan known.
0 Status is unknown.

NB) *1 Based on Needs Assessment Reports in 2003 and CPA Home Page (essential service)

*2 Available capacity in August 2004 taking ambient condition into consideration.

*3 Fuel type reported by CPA in May 2003 and subject to change

Type of Fuel

NG ::	Natural gas
CO :	Crude Oil
GO :	Gas Oil
FO :	Fuel Oil

Table-5.1-3 Status of Existing Power Generation Plants - Diesel Power Plant

Ref.No	Name of Plant	No, of Installed Unit	No.of Operable Unit	Unit Installed Capacity(MW) Unit Maximum Operable Capacity(MW)						Total Installed Capacity (MW)	Total Maximum Operable Capacity (MW) *2	Type of Fuel *3	Remarks
				1	2	3	4	5	6				
D-1	Erbil DPS	4		7.25	7.25	7.25	7.25			29		DO	
			4	7.25	7.25	7.25	7.25				29		
D-2	Dohuk DPS	4		7.25	7.25	7.25	7.25			29		DO	
			4	7.25	7.25	7.25	7.25				29		
D-3	Sulimaenia DPS	4		7.25	7.25	7.25	7.25			29		DO	
			4	7.25	7.25	7.25	7.25				29		
D-4	SDMO DPS *1	27		each 10						270		DO	
			27	each 8							216		
D-5	Mobile GenSets	Details unknown		Details unknown						60		DO	
											0		
D-6	Zaferina DPS	7		Details unknown						39		DO	
			7								36		
	Total	46	46							456	339		

(Small and Stanby Diesel Generator)

Northern 3 Govornarates	First batch(1999-2000)	377			31.8	
	Second batch(2000-2001)	601			65.7	
	WHO-funded(1999-2000)	171			9	
Central and South area	Electricity	662			117	
	Water & Sanitation	100			47	
	Health	815			142	
	Trans & Food Handling *4	1,399			502	
		4,125			**915**	

🟨 More than 10 years operation (commissioned before 1994)

▭ Rehabilitated/installed by 2003

🟦 Installation/Rehabilitation is underway.

Type of Fuel

NG ::	Natural gas
CO :	Crude Oil
GO :	Gas Oil
FO :	Fuel Oil
DO :	Diesel Oil

NB:

*1 SDMO: Solomon National Disaster Management Office

*2 Based on Needs Assessment Reports in 2003 and CPA Home Page (essential service)

*3 Fuel type reported by CPA in May 2003 and subject to change

*4 SDMO was substracted from UNDP report

Table-5.1-4 Status of Existing Power Generation Plants - Hydro Power Plant

Ref.No	Name of Plant	No. of Installed Unit	No. of Operable Unit	Unit Installed Capacity(MW) / Unit Muximum Operable Capacity(MW)						Total Installed Capacity (MW)	Total Muximum Operable Capacity (MW)	Remarks
				1	2	3	4	5	6			
H-1	Derbindikhan HPS	3		🟨 83	🟨 83	🟨 83				249		Not connected to National Grid
			2	🟩	🟨	🟩					165	
H-2	Dokan HPS	5		🟧 82	🟧 82	🟧 82	🟧 82	🟧 82		410		Not connected to National Grid
			3	🟩	🟧	🟧	🟩	🟩			168	
H-3	Himrin HPS	2		🟧 25	🟧 25					50		
			2	🟧	🟧						21	
H-4(1)	Mosul HPS (Main Dam)	4		🟨 187.5	🟨 187.5	🟨 187.5	🟨 187.5			750		
			4	🟦	🟦	🟦	🟦				600	
H-4(2)	Mosul HPS (Regulating Dam)	4		🟨 15	🟨 15	🟨 15	🟨 15			60		
			4	🟦	🟦	🟦	🟦				60	
H-4(3)	Mosul HPS (Pumped Storage)	2		🟨 120	🟨 120					240		
			2	🟦	🟦						120	*1
H-5	Hindia HPS	4		🟨 3.75	🟨 3.75	🟨 3.75	🟨 3.75			15		
			4	🟨	🟨	🟨	🟨				5	
H-6	Samara HPS	3		🟥 28	🟥 28	🟥 28				84		
			3	🟥	🟥	🟥					55	
H-7	Haditha HPS	6		🟨 110	🟨 110	🟨 110	🟨 110	🟨 110	🟨 110	660		
			5	🟨	🟨	🟨	🟨	🟨	🟨		160	
H-8	Al-Adhim HPS	2		⬜ 13	⬜ 13	⬜	⬜	⬜	⬜	0		Water
				⬜ 13	⬜ 13	⬜	⬜	⬜	⬜		0	
	Total	**33**	**29**							**2,518**	**1,354**	

- 🟥 More than 30 years operation (commissioned before 1974)
- 🟧 More than 20 years operation (commissioned before 1984)
- 🟨 More than 10 years operation (commissioned before 1994)
- 🟩 Rehabilitated/installed by 2003
- 🟦 Rehabilitation is underway
- ⬜ Not exist or no definitive plan known.

NB:
*1: This capacity can be increased to full capacity in future.

The total capacities of the existing plants are summarized as follows:

Table 5.1-5 Total Capacity of the Existing Power Plants

Type of Plant	No. of Plants	No. of installed units	No. of operable units	Total installed capacity (MW)	Total maximum operable capacity (MW)	Total available capacity de-rated by ambient temperature (MW)
Steam Turbine Plant	8	34	32	5,415	3,160	2,844
Gas Turbine Plant	14	71	67	2,261	1,741	1,423
Diesel Power Plant	6	46	46	456	339	305
Hydro Power Plant	7	33	29	2,518	1,354	1,354
Total	35	184	174	10,689	6,692	5,926

In this table, “Installed capacity” means the nameplate or rated capacity. “Maximum operable capacity” means the capacity which is de-rated based on long years of operation (= dependable capacity). “Available capacity de-rated by ambient temperature” means the capacity available in summer time, when de-rating occurs as a result of high ambient temperature and cooling water temperature. The available capacity de-rated by ambient temperature was evaluated specifically for each gas turbine plant and 90 % of “Maximum operable capacity” has been taken.

In Tables 5.1-1 to 5.1-4, the year of plant operation and the present status are illustrated with colored classification. The features of power generating plants are mentioned below.

1) Most of the steam turbine units are aged with more than 20 years of operation. Although many larger capacity units were rehabilitated or repaired recently, they were found difficult to restore to the nameplate capacity. Further rehabilitation or reconstruction/renewal should be studied.
2) Most of the gas turbine units have been operated over 20 years and are being rehabilitated or renewed by the summer of 2004. Comparatively, the older gas turbine units fueled by natural gas seem to be in good condition.
3) To meet the peak load of the 2004 summer, a considerable number of diesel generating plants are being implemented as independent installations, or being connected to the grid. Our survey could not cover all details of diesel power plants to be made available in the summer of 2004. However, some additional capacity would be available.
4) Hydropower plants share mainly daily peak load, but are subject to availability of water for power generating. A large difference between the installed capacity and de-rated capacity depends on this feature of hydropower generation.

5.1.2 Committed Projects

The power generating plants, of which construction works are now underway and expected to complete after the summer of 2004, are summarized as “committed” projects as follows:

Table 5.1-6 Summary of Committed Projects

Type of Plant	No. of Plants	No. of installed units	No. of operable units	Total installed capacity (MW)	Total maximum operable capacity (MW)	Total de-rated capacity by ambient temperature (MW)
Gas Turbine Plant	9	38	38	2,318	1,828	1,645
Diesel Power Plant	2	78	78	178	128	115
Total	11	116	116	2,496	1,956	1,760

The details of the above generating units are shown in Table 5.1-7. In cases where new generating units are added at the same site as existing units, those are counted as “committed plants”.

Table 5.1-7 Status of Committed Power Generation Plants

Ref.No	Name of Plant	No, of Installed Unit .	No.of Operable Unit	Unit Installed Capacity(MW) Unit Maximum Operable Capacity(MW)										Total Installed Capacity (MW)	Total Maximum OperableC apacity (MW) *1	Total Available Capacity derated by Ambient Temperature	Type of Fuel *2
				1	2	3	4	5	6	7	8	9	10				
G-6	Baji GPS	4		EX		159	159							318			FO/GO
			4			140	140								280	252	
G-7	Baji Mobile GPS	8		23	23	23	23	23	23	23	23			184			NG
			8	20	20	20	20	20	20	20	20				160	144	
G-11	Al Quds GPS	8		EX		125	125	43	43	43	43			422			CO/GO
			8			96	96	33	33	33	33				324	292	
G-16	Kirkuk New GPS	2		255	70									325			NG
			2	206	57										263	237	
G-17	Buzurgan GPS	1		43										43			NG
			1	35											35	32	
G-18	Baghdad South New GP	2		120	120									240			FO
			2	97	97										194	173	
G-19	Nasiriyah New GPS	1		40										40			CO
			1	32											32	29	
G-20	Musayab New GPS	10		50	50	50	50	50	50	50	50	50	50	500			CO
			10	35	35	35	35	35	35	35	35	35	35		350	315	
G-21	Hartha GPS	2		123	123									246			NG/CO
			2	95	95										190	171	
D-7	Northern IndustriesDPS	39		Details Unknown										78			DO
			39												63	57	
D-8	Baghdad WatGen DPS	39		Details Unknown										100			DO
			39												65	58	
	Total	**116**	**116**											**2,496**	**1,956**	**1,760**	

NB *1: Based on Report from CPA and MoE

*2 Fuel Type assumed from Existing Plant Data

*3 EX : Exsisting Plant

Type of Fuel
NG :: Natural gas
CO : Crude Oil
GO : Gas Oil
FO : Fuel Oil
DO : Diesel Oil

In order to forecast a long term demand and supply, an assumption has been made for convenience that all committed projects will be commissioned by the summer time in 2005 to meet the maximum peak load in 2005.

However, the following reconstruction projects for power generation shown in Table 5.1-8, which are proposed to be implemented, are not included in the committed projects. When these projects are realized, the capacity of respective items will be added to the power generating capacity.

Table 5.1-8 Proposed Projects under Discussion

Name of Project	Details of Projects	Additional capacity (MW)
Taji GPS Restoration (Phase-1)	Replace Generators #1, #2, #3, #5 with new ones	28
Taji GPS Rehabilitation (Phase-2)	Rehabilitate Generators #4, #6, #7	12
Mosul GPS Rehabilitation （Phase-1）	Replace Generators #1, #3 with new ones.	8
Mosul GPS Rehabilitation （Phase-2）	Rehabilitate Generators #2, #4	4
Mosul HPS Restoration	Supply and replacement work for four units of 187.5 MW Generators. Replace bearing pedestal, governor, exciter, etc.	120
Musayab TPS Restoration	To recover #2 generator from 100MW to 200MW, Inspect and supply parts for boiler, control, auxiliaries.	80
Musayab TPS Parts Supply for circulating water pump	Supply spare parts for circulating pump.	
Hartha TPS Parts supply for #1 & #4	Supply parts for #1, #4	50

5.2 Transmission Lines

Rehabilitation and implementation of new projects under the CPA have been continued by PMO Contractors and the task force of MoE as given in Table 5.2-1. However, the actual status of construction progress for the respective substations has not been confirmed due to the current conflict.

Table 5.2-1 Construction/Rebuilding of Substations

No.	Line	Voltage	Remarks
1.	Jazair-Yarmook	132 kV	To complete July 5, 2004
2.	Samediay-New Baghdad	132 kV	To complete July 5
3.	Burzulgan - S. Amara	132 kV	Completion to be June 25

4.	Nasiriya-Khor Zbayr	400 kV	Target complete Nov-03. To be completed June. Line being energized in sections.
5.	Dibis-Azadi-Quarqush	132 kV	To be completed May 22
6.	Dibis-Old Kirkuk Double Circuit	132 kV	To be completed Jul 31
7.	Dibis-Azadi	132 kV	To be completed May 22

The following transmission lines are considered for reinforcing the power system reliability of the northern region and Baghdad lines.

Table 5.2-2 Rehabilitation of Substations

No.	Substations Name	Voltage	Construction
1.	HadithaHP-Baiji	400 kV	Rebuild
2.	Mosul-Erbil	400 kV	Rebuild
3.	Erbil-Kirkuk	400 kV	Rebuild
4.	Haditha HP-Qaimi	400 kV	Rebuild
5.	Tuz-Zalar	132 kV	Rebuild
6	Kirkuk-Chamchamal	132 kV	Rebuild

5.3 Substations

MoE has continued to construct new or associated expansion of the generating plant and the existing substations. According to the CPA portfolio for the power sector to meet the power demand in summer 2004 the following substations are scheduled to be completed or under contract.

(1) New substations

Al Ameen GIS 400/132 kV Substation with 4 units of 250MVA capacity, which is located in Baghdad, will be tapped from 400 kV Baghdad East and Baghdad South lines.

Al Resheed GIS 400/132 kV Substation with 4 units of 250MVA capacity will be also located in Baghdad for interconnection with Yuosifiya GPS/TPS and Baghdad West substation.

(2) Extension of associated substations for generation expansion

According to the rehabilitation and expansion programme for power generation, the following substations are committed.

Table 5.3-1 Expansion of Substations

No.	Substation name	Voltage	Remarks
1.	W. Baghdad	400 kV	One bank for Al Resheed line
2.	Jamia	132 kV	Extension for Al Rasheed line
3.	Jaza'er	132 kV	Extension for Al Rasheed line
4.	Yuosifiya	400 kV	One diameter for Al Resheed line
5.	Babel	400 kV	One diameter for Yusefiya line
6.	Jameela - Rashdiya	132 kV	Extension for additional line
7.	Taji - N Baghdad	132 kV	Extension for additional line
8.	DouraPS - Eskanderiya	132 kV	Extension for additional line
9.	Kirkuk - Diyala	400 kV	Extension for additional line
10.	Nassiriya PS - Diwaniyah	400 kV	Extension for additional line
11.	Khor Zabayr PS - Hartha PS	400 kV	Rehabilitation for existing line

The on-going/committed and planned projects for transmission lines and substations for the 400 kV power system are shown in Figure 5.3-1

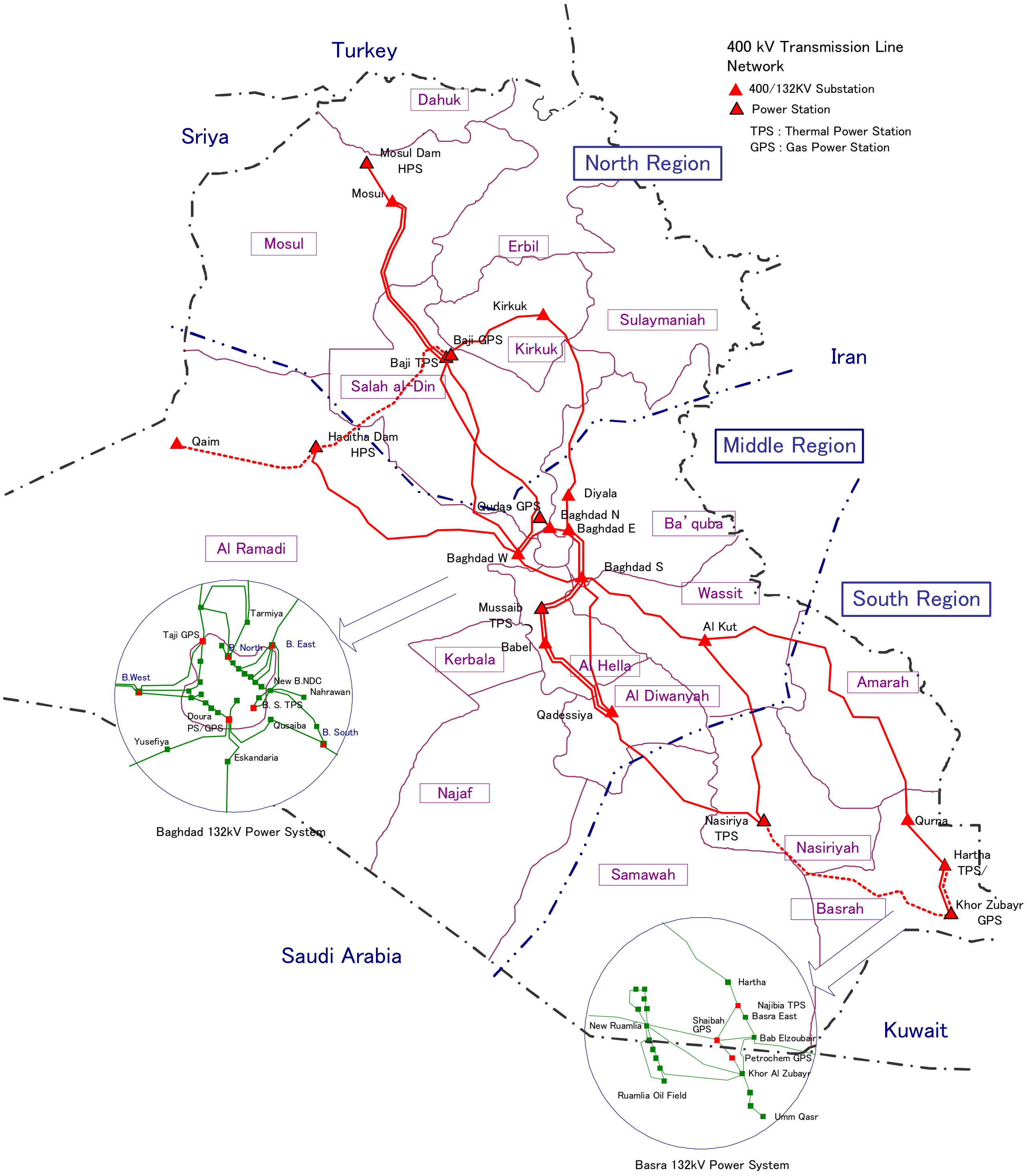


Figure 5.3-1 On-going/ Committed and Planned Projects for T/L and S/S for the 400 kV Power System

5.4 Distribution Networks

MoE has continued to rehabilitate the distribution network system to improve the power supply reliability. The distribution systems for three northern governorates were once conducted by UNDP under ENRP and continuously developed by the Local Electrical Authority (LEA). The rehabilitation, refurbishment and replacement of the distribution network system covers 33kV, 11kV and 0.4 kV low voltage system. In addition to the rehabilitation works, new distribution networks are also implemented to resolve the local power supply problems. Exact data for rehabilitation and development plans for the distribution network is not available.

5.5 Load Dispatching Facilities

The National Dispatching Centre (NDC) is rehabilitated with a new system to improve the power system operation. The UNDP will prepare the bid document for SCADA equipment for NDC and take the steps for the bidding, for which finance is provided under the Japanese Government Fund.

The main task of the NDC is to do real time monitoring for economic dispatching of the power generation and increasing power supply reliability in the country.

The new system includes the following control and functions.

- Network supervision
- Execution of switching operations
- Frequency control
- Voltage control
- Economic dispatch
- Disturbance analysis
- Network security assessment
- Interconnection assessment
- Hydro-thermal coordination

The following provisions are to be implemented in the SCADA system.

- Determine existing network conditions
- To balance the generation and consumption and to coordinate electricity generation, transmission and distribution
- To control any failure that occurs in dispatching operation and its equipment
- To regulate the frequency of the integrated system and to establish a rule, take control, supervise and coordinate in order to keep static and dynamic stability with minimum loss
- To plan and execute disconnection and limiting of the customers in case of incidents
- To develop long term estimates of consumption for the main network every year

- Analyze the weakest points
- Improve the network structure
- Optimize the network operating management
- Increase the supply reliability and security
- Decide on the required reactive power compensation and filter circuit system
- Investigate and improve network stability
- Plan network expansions
- Monitor network and equipment for maintenance, inventory checks and reporting

For the realization of the above SCADA system, MoE had a plan to install the communication link by OPGW for the 400 kV transmission lines under the MoU contract under the Oil-for-Food Program. However, the plan was partly implemented and the rest has not yet been processed.

Emergency projects required for load dispatching have been implemented by MoE and USAID.

(1) Relocation of PLC equipment to cover the communication gap among the substations (MoE Fund)

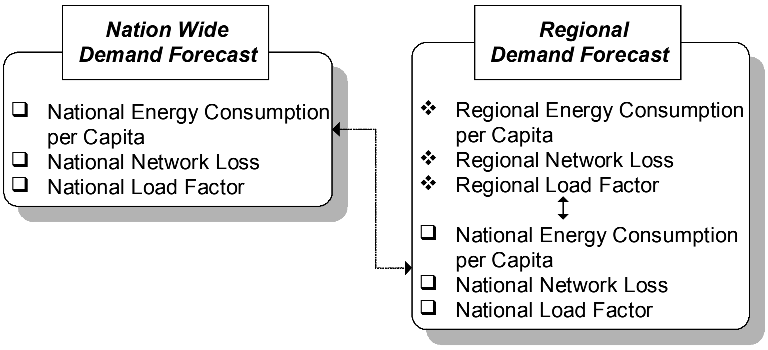
(2) Reconstruction of the Middle Regional Control Centre which was damaged due to vandalism and looting (MoE and USAID)

(3) Rehabilitation of Distribution Dispatching Centers by VHF radio communication (USAID)

Following the above, the upgrading of the 400 kV line communication system, rehabilitation of the 132 kV line communication system and upgrading of the distribution network communication system and associated projects, such as modernization of the existing power and substation control system, are required to be implemented.

CHAPTER 6 DEMAND FORECAST

6.1 General Flow



The Team forecast the demand in terms of both the nation wide and the regional levels.

The nation wide demand forecast mainly focuses on overall characteristics of the energy demand and the power system, while the regional characteristics reflect the regional demand forecast. The approach and procedure used for the two demand forecasts are principally same, and each forecast is adjusted so that there is no significant different result in the two forecasts. Results of the demand forecast will be used as an input for the generation expansion plan and also the power flow analysis.

Regarding the energy demand, it is noted that the category demand has not been considered because there is neither sufficient nor reliable data available for each category of load. Even though some comments on the energy consumption by category are given in this report, it is recommended that the category demand be considered when future development images become clearer.

6.2 Review of Past Study on Demand Forecast

In order to forecast the future demand of Iraq, the Team utilized the following reports as references.

Table 6.2-1 Reports Referred to for Demand Forecast

No.	Title	Issued by	Date of Issue	Prepared for
1	10 Years Plan of Commission of Electricity	COE	2002	Achieving COE's aim and task on electricity supply
2	Summary of Power Station Augmentation Project in Iraq (Revision 3)	UN	12 June 2002	Power station augmentation projects under Oil-for-Food programme
3	Load Forecast Report Iraq's Electricity Sector Projected Peak Demand, MCR-Based Available Capacity and Generation Deficit/Surplus	UNOHCI	December 2002	Assessing the required generation capacity to meet the growing demand

4	Observation Brief on the Energy Sector of Iraq (Revision 3)	UNDP	June 2003	Briefing to the World Bank
5	Electricity Network Development Plan – Erbil Governorate (Revision 1) Sulaimany Governorate (Revision 1) Dohuk Governorate (Revision 2)	UNDP	July 2003 February 2002 February 2002	Developing a suitable methodology to assess the existing situation and future electricity requirement in Erbil, Sulaymaniyah and Dahuk Governorates
6	Needs Assessment of the Electricity Sector of Iraq	WB	July 2003	Assessing the needs of the electricity sector especially on budget, fuel supply, environment/ energy efficiency issues, and institutional status
7	Needs Assessment of the Electricity Sector of Iraq (Revision 7)	UNDP/WB	5 October 2003	Assessing the needs of the electricity sector

(1) 10 Year Plan of Commission of Electricity

This is the only report prepared by the Iraqi Government that was available for reference.

Energy demand has been forecast only for the years 2001 to 2012. Capacity (peak) demand has not been estimated. The average annual demand increase is 9.1 %, which is calculated from the demand of 41,000 GWh in 2001 and 107,000 GWh in 2012. In the same way, the average increase for 10 years from the year 2001 to 2011 is 9.3 %, which is noted in the report. The applied annual increases are not constant, and different increases are applied for each year.

It is mentioned that the figure 41,000 GWh adopted as base demand in 2001 is the actual value. The forecast demands seem to be the required demand at the generating points of power stations because 41,000 GWh is consistent with the recorded data[1] at the generating points of power stations.

(2) Summary of Power Station Augmentation Projects in Iraq

This report is a summary of significant Iraqi power station augmentation projects either completed, in progress, or firmly planned where materials or services were sourced under the Oil-for-Food program.

The report does not address the demand forecast. It just refers to the estimated national peak demand of 8,000 MW in 2006 with an annual demand increase of 4 %.

This report is mentioned for general information, and is not a reference on the demand forecast for Iraq.

---

[1] WB Needs Assessment of the Electricity Sector of Iraq, Annex F Energy Statistics; 2003

(3) Load Forecast Report

The Load Forecast Report was prepared in December 2002 in order to assess a balance between demand and capacity up to the year 2010, in the Iraqi power system. In this report, only the peak demand (capacity demand)[2] of the whole country is forecast and energy demand is not dealt with.

The estimated demands are on the consumer level and three cases are considered. The base forecast, high forecast and low forecast were prepared by applying annual growth rates of 4.0 %, 6.0 % and 2.5 % respectively, from the year 2002 to 2010. The base forecast growth rate of 4 % has been adopted reflecting the real growth of peak demand in the year 2001 to 2002, which is approximately 3.5 to 4 % based on the data obtained from the observations at the distribution offices. The high forecast growth rate of 6 % is applied as the case of greater economic growth of Iraq and is at the same level as surrounding countries such as Egypt and Turkey. The low forecast growth rate of 2.5 % applies to the case where only the growth of residential demand is considered.

The peak demand for the whole country in the year 2002, which is called the reference peak demand, is 6,448 MW. This figure was worked out based on the data collected from observation visits to the distribution offices in the 15 governorates of the Center and Southern regions and from the UNDP-ENRP (Electricity Network Rehabilitation Programme) for the three northern governorates. The individual peak demands of each governorate for summer and winter in 2002 are tabulated in the report, and the reference peak demand is the aggregation of the governorates' demand in summer.

The deficits and surplus in power supply capacity are estimated comparing the forecast peak demand and actual available supply capacity to the consumers taking into account the Maximum Continuous Rating (MCR) of power stations, a reserve margin of the estimated peak demand (10 %), and transmission and distribution losses[3] (10 %) of the available capacity of power stations on a sent-out basis.

(4) Observation Brief on the Energy Sector of Iraq

The report was prepared based on the observation visits conducted by the ELSG for the 15 governorates in the center and southern regions and the information from ENRP for the three northern governorates.

Regarding demand forecast, the same data and results as the Load Forecast Report are presented with some clarification in this report, which means that the forecast mentioned in the report is peak demand forecast from the year 2002 to 2010 with the annual demand growth rates of 4 %, 2.5 % and 6 %.

---

[2] The Team defines peak demand and capacity demand as having the same meaning.

[3] 10 % of transmission and distribution losses seem to be much lower than the actual figure. The writer of the Load Forecast Report also stated the same thing in the report. That is, it is mentioned in the report that because of no reliable data about transmission and distribution losses, only general industry guidelines can be used.

(5) Electricity Network Development Plan – Erbil, Sulaymaniyah and Dahuk Governorate

This report sets out the overall plan for the reinforcement and improvement of the distribution networks in the Erbil, Sulaymaniyah and Dahuk governorates.

The peak (capacity) demand of Erbil, Sulaymaniyah and Dahuk governorates, which is measured at the substation exits of the 11 kV and 33 kV feeders, is forecast from the year 2000 to 2020. There is no energy demand forecast. The base peak demand in 2000 is estimated by the maximum loads of 11 kV and 33 kV feeders of the substations in Erbil, Sulaymaniyah and Dahuk, which were recorded in January and/or August through 1994 to 2000. The maximum loads of the feeders were aggregated applying diversity factors ranging from 0.8 to 0.9, and then the peak demand of the governorates has been calculated. The future demands are forecast by applying target electrification ratios, consumer growth rates, bulk load increase ratios, and considering the increase of peak power consumption per consumer. For these parameters, expected or assumed values have been applied.

The peak demand of Erbil, Sulaymaniyah and Dahuk in 2000 has been estimated at 326 MVA, 381 MVA and 169 MVA, and in 2020 is forecast at 1,038 MVA, 1,183 MVA and 374 MVA respectively in the reports.

(6) Needs Assessment of the Electricity Sector of Iraq (WB)

This report was prepared in collaboration with UNDP. The collaboration team is the same team that prepared the UNDP/WB's Needs Assessment report (refer to No.7 below).

This report does not deal with demand forecast, but Annex E: Customer Service Issues and Annex F: Energy Statistics of the report contain useful data and information for conducting demand forecast.

(7) Needs Assessment of the Electricity Sector of Iraq (UNDP/WB)

Revision 7 of the Needs Assessment of the Electricity Sector of Iraq is the latest report that the Team referred to for demand forecast.

Peak demands are forecast from the year 2003 to 2012. As the peak demand in 2003, 6,300 MW has been applied. This figure seems to be estimated from the resultant peak demand 6,448 MW of the country in the 2002 summer. For 2004, an increase of 12 % has been assumed and this results in a demand of 7,056 MW, which is referred to as the base peak demand. For the year 2005 to 2012, the peak demands are forecast with annual growth rates of 4 %, 6 %, 8 % and 10 %. The annual growth of 8 % is taken as the base forecast for long term planning. The data and approach to the demand forecast are derived from the Load Forecast Report and in consultation with MoE staff.

The forecast peak demand is taken as the load requirement at the medium voltage (33 and 11 kV) substations in the distribution system. This approach is different from that of the Load Forecast Report in which the forecast demand is taken as the demand required at the consumers' end. By that thinking, the forecast demand in the Needs Assessment report is to include distribution losses. Accordingly, only the transmission losses of 3 % are considered on the available sent-out capacity of power stations to estimate the power deficits and surpluses.

As a result of the review of documents and information dealing with demand forecast, major findings are as follows:

- There is a lack of reliable data and information for demand forecast;
- Only peak (capacity) demand is forecast except for the forecast in the 10 Year Plan of COE;
- The main source of data is the Load Forecast Report;
- The methodology of the demand forecast for both peak (capacity) and energy has been to apply demand increase ratios; and
- There is insufficient background to rationalize the demand increase ratios.

The above is understandable given the lack of records and planning processes within the MoE. Also the actual demand has not been able to be supplied for a number of years. Suppressed demand is always difficult to estimate and this is particularly so in Iraq because of the rapidly changing social, economic and security situation.

The following figure summarizes the results of current peak demand forecasts in the reports, No.7 Needs Assessment of the Electricity Sector of Iraq and No.4 Observation Brief of the Energy Sector of Iraq.

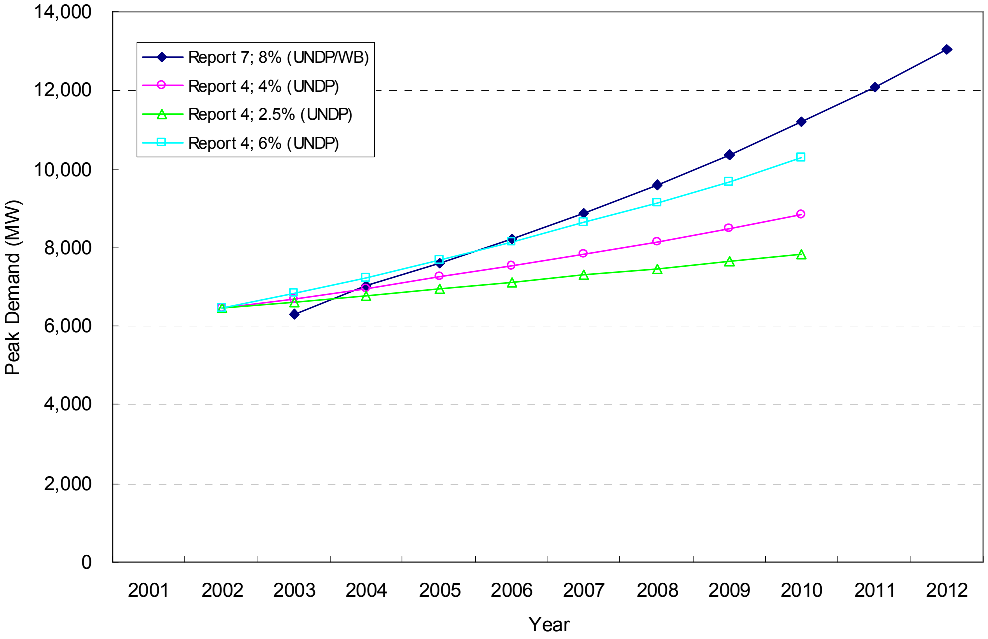


Figure 6.2-1 Peak Demand Forecast in the Other Reports

6.3 Present Constrained Demand

By using information from the above reports and recent information from MoE staff and the CPA web site, the current relationship between electricity demand and supply side can be represented as shown in the following figure.

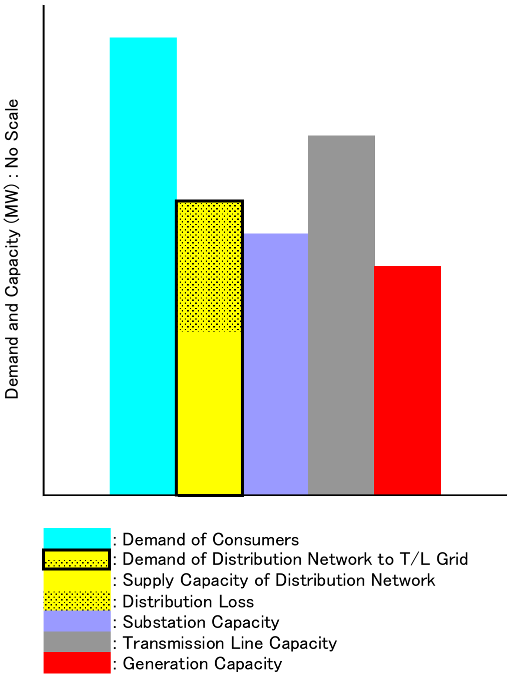


Figure 6.3-1 Image of Current Electricity Demand and Supply Capacity

Based on the observations in Chapter 3 (Past and Current Status of Power Sector), the current electricity supply capacity appears to be insufficient at all stages of the power generation, transmission, substation and distribution electricity supply facilities. In particular, the capacity of the power generation facilities seems to be significantly deficient against the current demand. In addition, losses at the distribution level might also be high.

As a result, the current situation on the electricity supply side constrains the demand of consumers.

When the above is taken into consideration along with the plans to rehabilitate and expand the system, the relationship between demand and supply can be illustrated as shown below.

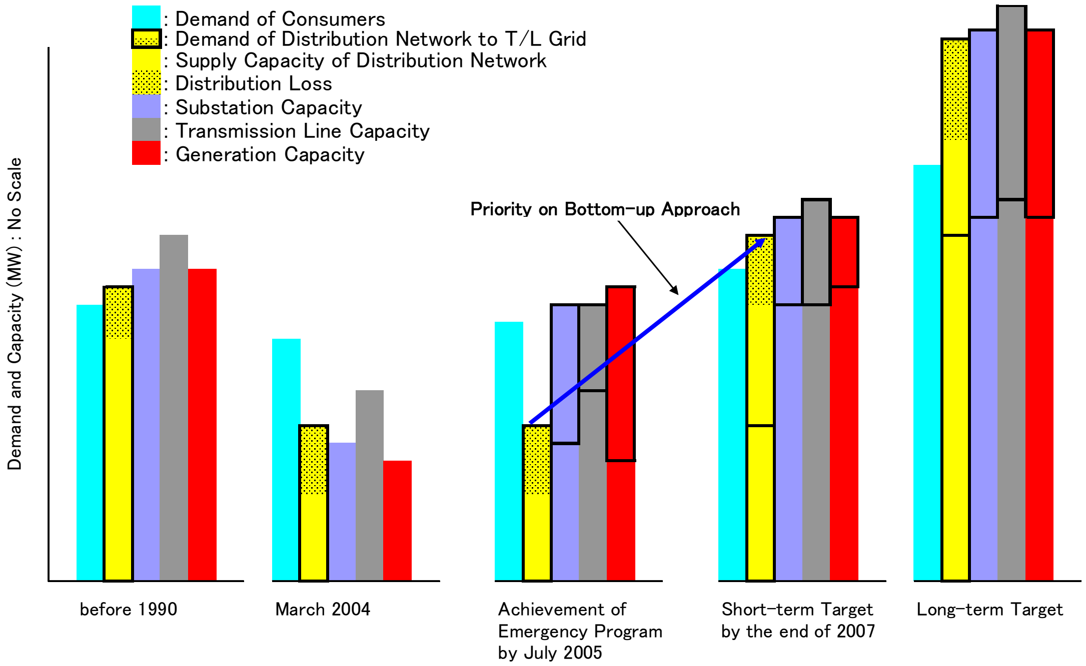


Figure 6.3-2 Image of Electricity Sector Development Process

After the recent conflict in 2003, the parties concerned have made a lot of effort for the electricity sector. However, most of the rehabilitation or reconstruction activities have been concentrated on power generation and transmission facilities, and activity in the distribution sectors appears to be well behind the others. In other words, the constraint situation is not much improved at the consumers' level. Consequently, development of the distribution facilities might be a key to grow the demand up to a favorable level in the short to middle term period. Through loss reduction and/or appropriate demand side management, an efficient and balanced development of the electricity sector could be anticipated in the long term.

6.4 Nation Wide Demand Forecast

6.4.1 Approach

The main purpose of the nation wide demand forecast is to estimate an electricity requirement at the sent-out points of power stations, where the network receives electricity.

The required electricity is measured in two ways, energy demand and peak demand. As mentioned in Chapter 6.1 (General Flow), the basic approach of the nation wide demand forecast is that the peak demand is estimated from the assumed energy demand, transmission / distribution losses and load factors. In addition, the forecast starts from assuming the energy demand at the consumers' end.

6.4.2 Available Data

The available data, which is useful for the nation-wide demand forecast, is listed below:

- Population 1957 to 2003 (UN-HABITAT, WFP)
- Energy consumption at consumers' end 1990 (UN-HABITAT)
- Energy production 1990 to 2002 (MoE)
- Peak load 1990 to 2001 (MoE)

6.4.3 Estimation of Present Potential Demand

In order to estimate the present (2004) potential electricity demand of Iraq, the Team has assumed that the present level of electricity consumption per capita is not less than that before the 1st Gulf War.

Before the 1st Gulf War, the maximum consumption was recorded in 1990[4]. According to the data obtained from UN-HABITAT, the annual electricity consumption of Iraq is 20,444 GWh. This figure is assumed to be the electricity consumption at the consumers' end because the data has been sorted by category and governorate[5].

The total population of Iraq in 1990 was 17,890,000 as shown in Appendix B.1. Using this data, the annual electricity consumption per capita of Iraq at the consumers' end in 1990 is calculated at 1,143 kWh.

The population of Iraq from 1970 to 2003 and the percentage increases are shown in the following table.

---

[4] Annex E Customer Services Issues, Needs Assessment of the Electricity Sectors of Iraq, WB, 2003.

[5] It is difficult to consolidate the recorded data in power stations and substations in such a manner because the sent out electricity cannot be identified into each governorate and category.

Table 6.4-1 Population and Its Annual Increase Ratios

Year	1970	1980	1990	2000	2003
Population (thousand)	9,440	13,238	17,890	23,577	25,898
Annual Increase Ratios	3.44 %	3.06 %	2.80 %	a) 3.18 % for 2000-2003, b) 2.96 % for 1970-2003	

Source: UN-HABITAT[6] for 1970 to 2000 and WFP for 2003

In order to estimate the present population in 2004, the annual average increase ratio from 1970 to 2003, that is, 2.96%, is applied to the population of 25,898 thousand in 2003, and then the population in 2004 comes to 26,665 thousand.

From the per capita consumption of 1,143 kWh in 1990 and the above estimated population of 26,665 thousand, the present potential energy demand in 2004 at the consumers' end is estimated at 30,478 GWh.

6.4.4 Transmission and Distribution Losses

In order to estimate the transmission and distribution losses, reference is made to the annual energy production and consumption in 1990. The energy production data from MoE indicates that the annual energy production was 29,469,350 MWh. This figure includes in-house consumption and losses & meter reading errors, around 5 % and 1 %, respectively. Hence, annual sent-out energy in 1990 is calculated at 27,701 GWh. On the other hand, the annual energy consumption at the consumers' end is 20,444 GWh from the data of UN-HABITAT. Using these two values, energy losses in transmission and in the distribution system are calculated at 26 % of the annual sent-out energy. This is somewhat on the high side.

The above losses represent the normal power supply situation before the 1st Gulf War. Following the 1st Gulf War in 1991 and the recent conflict in 2003, the condition of the transmission and distribution systems have deteriorated considerably. As, for the time being, there is no way to estimate the current transmission and distribution losses, the Team has assumed the said losses to be 33 %.

The losses include the technical and non-technical losses and will be reduced gradually during the progress of rehabilitation and reinforcement work on the system and institutional setup for power supply operation. The Team has estimated the future transmission and distribution losses as tabulated below.

---

[6] The data sources of UN-HABITAT are Iraq Population Censuses 1957, 1965, 1977, 1987, and 1997. Thus the population figures after 1995 or 1996 seem to be estimated values.

Table 6.4-2 Transmission and Distribution Losses

	Actual	Assumed						
Year	1990	2004	2005	2006	2007	2008 to 2010	2011 to 2015	2016 to 2020
Loss Ratios (%)*	26	33	32	30	28	27 - 26	25 - 23	22 - 20

Note *: Percentage against annual sent-out energy of power stations

6.4.5 Load Factors

Annual load factors have been obtained from annual energy production and annual peak load recorded in the generation statistics as shown in the following table.

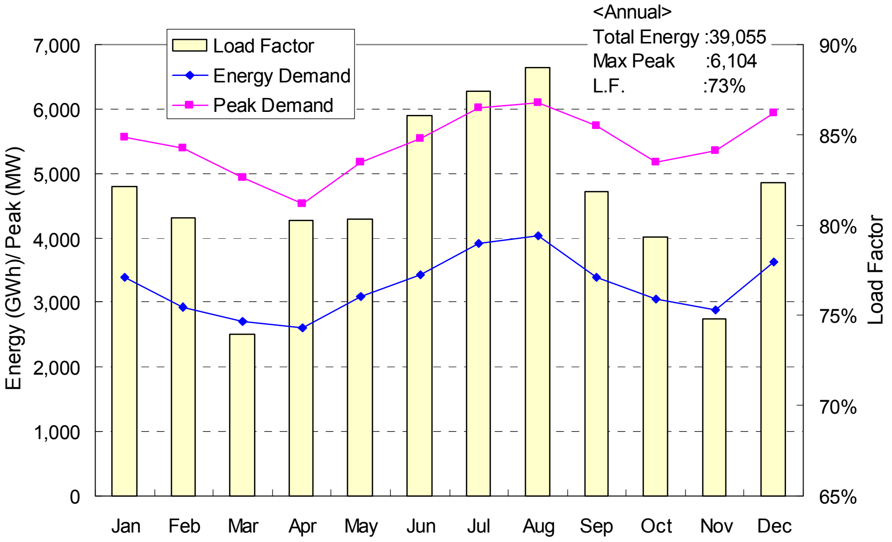
Table 6.4-3 Annual Load Factors from 1990 to 2001

Year	Annual Peak* (MW)	Annual Energy* (GWh)	Annual Load Factor
1990	5,162	29,469	0.65
1991	3,920	16,202	0.47
1992	4,733	28,051	0.68
1993	4,926	28,355	0.66
1994	4,701	29,160	0.71
1995	4,913	28,600	0.66
1996	4,804	27,838	0.66
1997	4,615	28,783	0.71
1998	4,541	29,139	0.73
1999	4,350	27,201	0.71
2000	4,616	29,126	0.72
2001	5,301	33,213	0.72

Note *: at P/S Generating Points
Source: The energy production data from MoE

The load factor varies in the range of 0.65 to 0.73. Due to the 1st Gulf War, the annual energy production was reduced in 1991, which is reflected by the low load factor. The load factor in 1990 appears to represent a value under the typical power supply norms.

Figure 6.4-1 shows average energy demand, peak demand and load factor of the whole of Iraq on a monthly basis, which have been estimated by MoE (NDC: National Dispatch Center) for 1999 to 2002. It is noted that both of the demands are at P/S generating points.



Data source: MoE (NDC) estimate

Figure 6.4-1 Average Energy Demand, Peak Demand and Load Factors 1999 to 2002[7]

As indicated in the figure, energy demand, peak demand and load factor changes are synchronized with each other. The maximum load factor in August reaches nearly 90 %, while annual load factor and the load factors in March and November, which are the turn of the seasons, are 73 % to 75 %.

The Team has forecast the present and future load factors as follows:

Table 6.4-4 Forecast Annual Load Factors from Year 2004 to 2020

Year	2004 to 2005	2006 to 2007	2008 to 2010	2011 to 2015	2016 to 2020
Annual Load Factor*	0.75	0.72	0.70	0.69 - 0.65	0.66 - 0.70

Note *: Annual Load Factor = (Annual average power) / (Annual peak power)

As mentioned in Chapter 6.4.1 (Approach), one purpose in forecasting the annual load factors is so that peak demand can be calculated from annual energy demand. The locations where the network receives electricity and where the demand is measured are the sent-out points of the power stations. Hence, the load factors should represent the characteristic of electricity requirement at the sent-out points. The estimated demand can then be directly compared with the generating capacity of the system.

In 2001, the load factor was 0.72. The current transmission and distribution capacity is much worse than that in 2001. Therefore, the capacity is likely to be suppressed. Because of this consideration, 0.75 has been adopted as the load factor in 2004 to 2005. The condition of the transmission and distribution network will be improved

---

[7] Sulaymaniyah and Erbil are not included in the data.

eventually. Along with the improvement, constraint of capacity will be reduced, and the peak capability will increase. Based on this assumption, 0.72, 0.70 and 0.65 are applied as load factors in 2006 to 2007, 2008 to 2010 and 2011 to 2015 respectively. A higher load factor would be preferable if there are no constraints from the view point of efficient power plant operation. From 2016, it is expected that demand side management will result in some effects especially for reducing the peak. With this expectation, 0.7 is adopted as the load factor in 2016 to 2020, which is the same as in 2008 to 2010. It is noted, however, that the figure of 0.70 in 2016 to 2020 is derived from the expected demand side management (DSM) under a no constraint condition of transmission and distribution system.

6.4.6 Base Scenario of Nation Wide Demand Forecast

Based on the above examination of potential demand, transmission / distribution losses and load factors, the base scenario of the nation wide demand forecast is summarized below.

Table 6.4-5 Base Scenario of Nation Wide Demand Forecast

Year	Energy Damand at Cosumer Ends (GWh)	T/L and D/L Loss Ratio* (%)	Energy Damand at P/S Sent-out Points (GWh)	Load Factor	Peak Damand at P/S Sent-out Points (MW)
2004	30,478	33	45,490	0.75	6,924
2005	31,392	32	46,165	0.75	7,027
2006	33,276	30	47,537	0.72	7,537
2007	35,272	28	48,989	0.72	7,767
2008	38,094	27	52,184	0.70	8,510
2009	41,142	27	56,359	0.70	9,191
2010	44,433	26	60,045	0.70	9,792
2011	47,543	25	63,391	0.69	10,488
2012	50,871	25	67,829	0.68	11,387
2013	54,432	24	71,622	0.67	12,203
2014	58,243	24	76,635	0.66	13,255
2015	62,320	23	80,935	0.65	14,214
2016	66,059	22	84,691	0.66	14,648
2017	70,022	22	89,772	0.67	15,296
2018	74,224	21	93,954	0.68	15,773
2019	78,677	21	99,591	0.69	16,477
2020	83,398	20	104,247	0.70	17,001

Notes * : Percentage against annual sent-out energy of power stations

Annual Increase Ratios

2004 to 2005	3 %
2005 to 2007	6 %
2007 to 2010	8 %
2010 to 2015	7 %
2015 to 2020	6 %

The assumption of annual increase ratios is based on the following considerations:

2004 to 2005 Because of a lack of improvement for distribution facilities, increase of the demand is suppressed to a low rate.

2005 to 2007	As reconstruction activities in the electricity sector are being progressed, the economics are beginning to grow.
2007 to 2010	Based on the recovered infrastructure, the demand grows at a high rate.
2010 to 2015	It has passed 10 years after the reconstruction activities had started. The demand growth becomes gentle.
2015 to 2020	Effects of captive power installation and DSM emerge.

The peak demand in 2004 is estimated at about 7,000 MW. Afterwards, the peak demand is increased to 7,800 MW in 2007, 9,800 MW in 2010, 14,200 MW in 2015 and 17,000 MW in 2020, respectively.

Our peak demand at the sent-out point of power stations is illustrated below with the peak demand in the other reports.

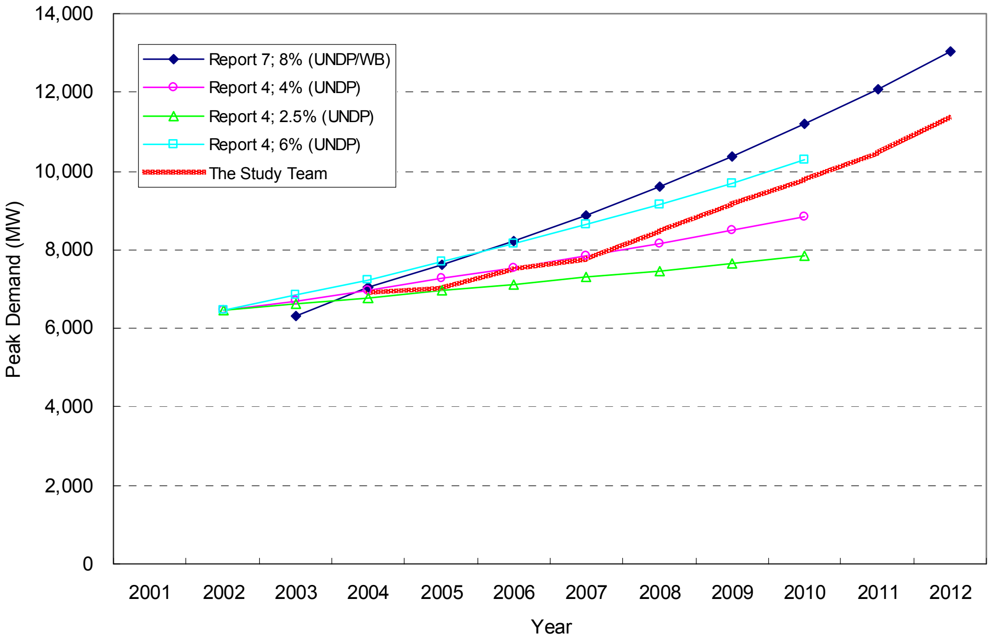


Figure 6.4-2 Peak Demand of Nation Wide Forecast

6.4.7 Demand Side Management

As discussed in Chapter 6.4.5 (Load Factors), demand side management (DSM) is expected to become effective in the middle to long term period.

In terms of stable power supply and economical power system development, an appropriate balance between energy consumption and peak load, which is expressed as load factor, is required. A higher load factor is preferable if there are no constraint conditions and the power system capacity has the necessary reserve margin.

Introduction of DSM will have a considerable impact especially in reducing the peak demand. One of the DSM measures is the application of a power tariff during peak and off-peak times. It aims to transfer a part of the demand in peak time to off-peak. Other DSM measures, such as heat storage systems or fuel cells (storage of the hydrogen energy) are becoming conceivable for the near future.

6.4.8 Other Scenarios for Demand Forecast

In the base scenario, the energy and power demand are estimated from the energy demand per capita, the network losses and the load factors. Apart from such parameters, some other considerations on the demand forecast are discussed below.

(1) Encouragement of Captive Power Installation

According to the UNDP Observation Brief on the Energy Sector of Iraq (June 2003), it is reported that the total installed capacity of standby generators in Iraq, excluding the three Northern governorates, was 916 MW as of February 2003. This power was used for the electricity sector, the water / sanitation sector, the health sector and the transportation / food handling sector. It is not certain how many of these generators currently work properly. However, the capacity is significant and cannot be neglected.

In general, large scale industries such as the steel industry, the cement industry, the petrochemical industry and the oil refineries own captive power for their demand. In terms of efficient power system development, it is recommended that captive power installation be encouraged.

(2) Encouragement of Renewable Energy Application

In addition to the above, renewable energy also will be possible in the middle to long term period. Renewable energy such as solar power and/or wind energy can be effective, especially for the electrification of off-grid areas. Any application of such energy depends on its potential. The electrification of off-grid areas will lead to a balanced power system development for the Iraqi people.

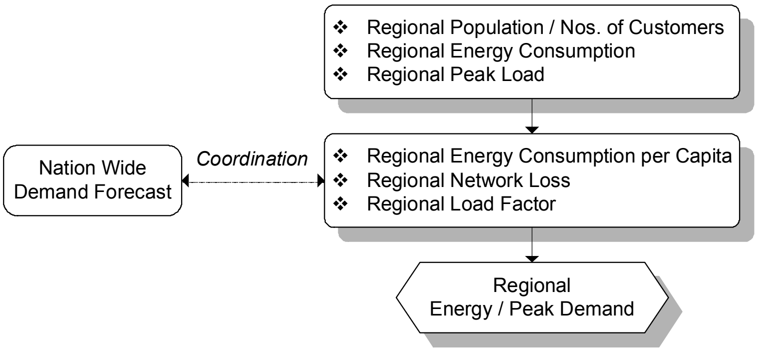
Based on the above considerations, captive power installation might be encouraged in the middle term period from 2011 to 2015. In the long term period from 2016 to 2020, renewable energy, as well as captive power installation, is expected to be applied widely in the whole country.

From the middle to long term point of view, use of such energy sources will affect the demand from the grid. The demand forecast should take such considerations into account.

6.5 Regional Demand Forecast

6.5.1 Approach

An approach to the regional demand forecast is basically the same as that of the nation wide demand forecast, that is, the peak demand is estimated from assumed energy demand and load factors at defined points taking the network losses into account. In addition, the result of the regional demand will be used as an input to the power flow analysis.



6.5.2 Available Data

Available past records, referred to for the regional demand forecast, are summarized in the following table.

Table 6.5-1 Available Data for Regional Demand Forecast

Year	Regional			
	Population	Nos. of Customers	Energy	Peak
1990	△	×	○	×
2001	△	○	○	×
2002	○	○	○	○
2003	○	×	CPA Daily Power Data	
2004	△	×	Aug. 2003 ~	

○: data available
×: data not available
△: data can be estimated
🟨 data referred in the regional demand forecast

Population:

- Population 1977, 1987 and 1997 (Population Census)
- Population 2002 (UN-HABITAT)
- Population 2003 (WFP)

Nos. of Consumers:

- CoE Consumers by Category & Region in 2001 (WB Needs Assessment of the Electricity Sector of Iraq, Annex E Customer Services Issues Rev 1; 2003)
- Overview of Distribution Consumers (UNDP Observation Brief on the Energy Sector of Iraq; June 2003)

Energy Consumption:

- Electricity Consumption by Governorate and Use in 1990 (UN-HABITAT)
- CoE Consumers by Category & Region in 2001 (WB Needs Assessment of the Electricity Sector of Iraq Annex E Customer Services Issues Rev 1; 2003)
- Total Electricity GCED (General Company for Electricity Distribution) Received vs. Sold by Region in 2000 and 2001 (same as the above)
- Network Energy Demand & Balance (MoE Generation & Energy Balance Report for 2001, 2002 Jan. ~ Dec.)
- Daily Power Data (CPA homepage; Aug. 2003~)

Peak Load:

- Distribution System Peak Demand (UNDP Observation Brief on the Energy Sector of Iraq; June 2003)
- Daily Power Data (CPA homepage; Aug. 2003~)

Referring to the above information, the regions in this report are defined as follows.

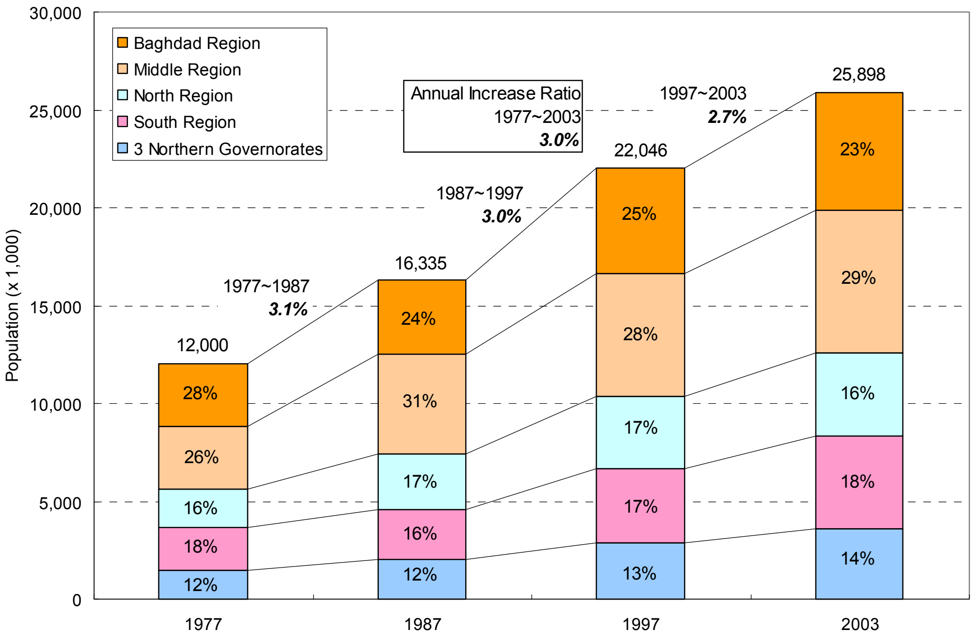
Table 6.5-2 Regions and Governorates

Regions	Governorates
Baghdad Region	(Rasafa & Suburbs) (Karkh & Suburbs)
Middle Region	Diyala Anbar Najaf Kerbela Qadissiya Wassit Babylon
North Region	Tameem Salah al-Din Ninewa
South Region	Basrah Muthanna Thi-Qar Missan
3 Northern Governorates	Sulaymaniyah Erbil Dahuk

6.5.3 Population and Number of Consumers

(1) Population

The regional population in 1977, 1987, 1997 and 2003 are summarized in the figure below. The details are given in Appendix B.2.



Data Source: 1977, 1987 and 1997 from Population Census, 2003 from WFP

Figure 6.5-1 Regional Population from 1977 to 2003

Through the above period, the annual increase of total population is around 3 %. The population of each region also grows at approximately the same rate. The population share of the Baghdad, Middle, North, South regions and 3 Northern Governorates are 25 %, 29 %, 17 %, 17 % and 13 %, respectively.

Based on the above population data and the area data for each region, the population density of each region has been calculated as tabulated below.

Table 6.5-3 Regional Population Density

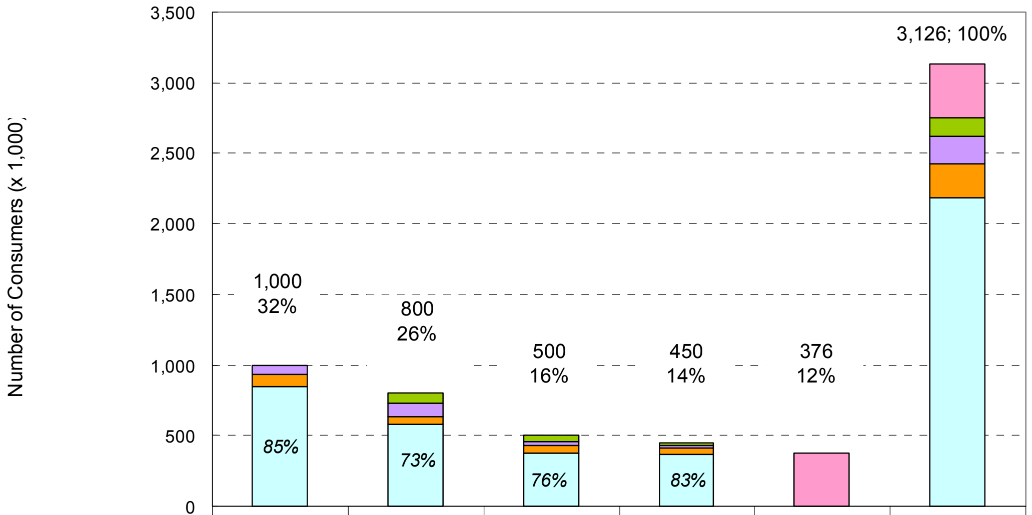
Unit: persons/km^2

Regions/ Year	1977	1987	1997	2003
Baghdad Region	4,346	5,233	7,390	8,207
Middle Region	14	23	28	33
North Region	27	39	51	59
South Region	22	26	38	47
3 Northern Governorates	39	53	75	96
Total Iraq	28	38	51	60

The Baghdad region is by far the largest population density among all regions. Comparing the population density of 2003 with that of 1977, 3 Northern Governorates have increased 3 times and other regions have increased twice during the past 26 years.

(2) Number of Customers

The number of customers estimated by UNDP in 2003 is shown in Figure 6.5-2.



	Baghdad	Middle	North	South	3 Northern Gov.	Total
□ All Category Total	-	-	-	-	376	376
□ Agricultural/ Others	8	68	42	15	N.A.	133
□ Industrial	55	96	25	19	N.A.	196
□ Commercia/ Others	87	55	51	43	N.A.	236
□ Household	850	580	382	373	N.A.	2,186

Data source: UNDP Observation Brief on the Energy Sector of Iraq; June 2003

Figure 6.5-2 Number of Consumers Estimated by UNDP

Comparing the regional population and the number of customers, the trend of the regional distribution is similar. However, the percentage of the total number of customers that are in the Baghdad region (32 %) is rather higher than that of the population in the Baghdad region (23 %). In terms of categories, the number of household customers shares 70 % to 85 % in all the regions except for the three northern governorates. According to the Electricity Network Development Plan for the Erbil, Sulaymaniyah and Dahuk governorates, the trend of number of customers in the governorates seems to be not much different from the other regions.

(3) Electrification Ratio

In relation to the number of customers, some issues on “electrification ratios” are discussed below.

Based on the population and number of households as of December 2002 and the number of residential customers in Figure 6.5-2, the electrification ratios of households by regions are estimated as shown in the following table.

Table 6.5-4 Regional Electrification Ratios[8]

Regions	Population (x 1,000)	Nos. of Household (x 1,000)	*Persons / Household*	Nos. of Residential Customers	Electrification Ratio of Household
Baghdad Region	6,132	915	*6.7*	850	93%
Middle Region	7,293	921	*7.9*	580	63%
North Region	4,242	537	*7.9*	382	71%
South Region	4,684	563	*8.3*	373	66%
Total the above 4 regions	22,352	2,936	*7.6*	2,186	74%

Data source: Population and Nos. of Households (as of Dec. 2002) data from UN-HABITAT, Nos. of Residential Customers data from UNDP Observation Brief on the Energy Sector of Iraq; June 2003

The UNDP Electricity Network Development Plans for Erbil, Sulaymaniyah and Dahuk reported that electrification ratios of each governorate are 67 %, 64 % and 70 %, respectively.

The Needs Assessment of the Electricity Sector of Iraq by UNDP and WB (October 2003) reported that approximately 87% of the population had access to electricity. This figure refers to the estimated data in the Observation Brief on the Energy Sector of Iraq by UNDP (June 2003). The Team found some inconsistent data in that the estimate of the number of non-connected customers in the report is much less than that of the calculated non-connected households, which is derived from other data.

The relatively low electrification ratio in the three northern governorates compared to the overall country can be attributed to the disruptions caused by the wars and rebellions which caused huge population shifts firstly across the borders to neighboring countries and then back.

Due to a lack of completely reliable data, it is difficult to definitely clarify electrification ratios at the moment. It is recommended that further data collection and analysis be carried out.

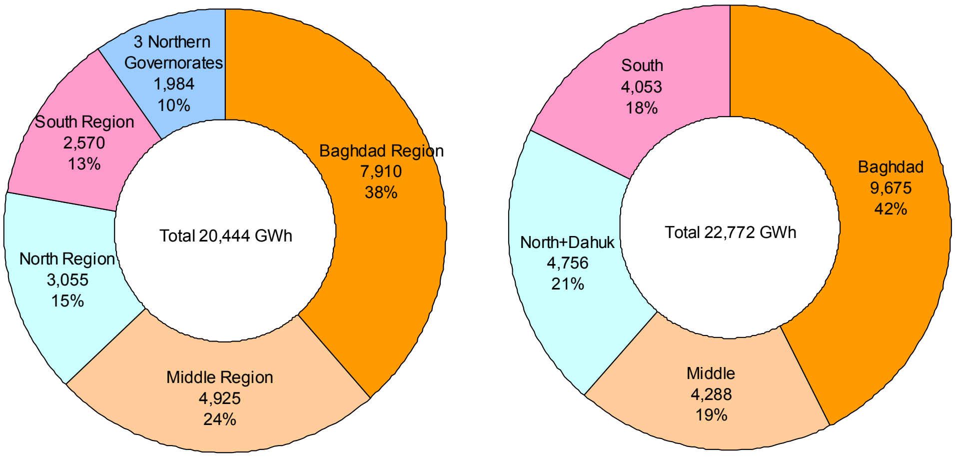
6.5.4 Regional Energy Consumption

(1) Regional Energy Consumption in 1990, 2001

Regional energy consumption at the consumers' end in 1990 and 2001 is illustrated in Figure 6.5-3. The details are given in Appendix B.4.

---

[8] 3 Northern governorates are not included in the data.



Data Source: UN-HABITAT

Figure 6.5-3 Regional Energy Consumption at Consumers' End in 1990 and 2001[9]

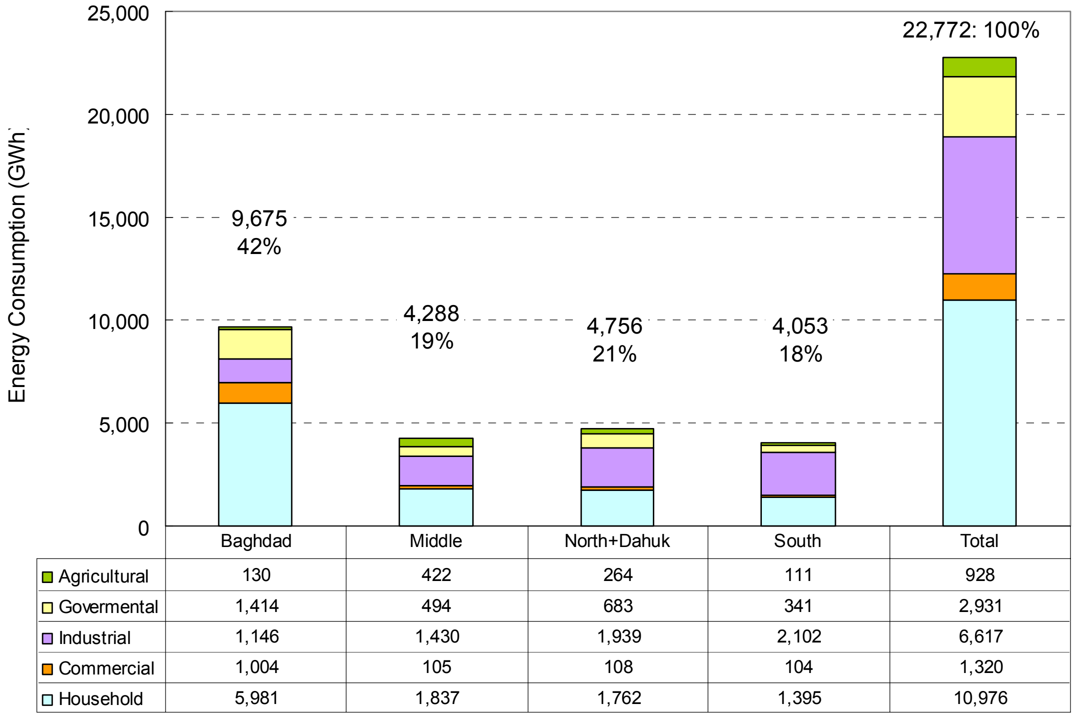
In 1990, the Baghdad and Middle regions consumed around 60 % of the total energy, and the remainder was shared almost equally among the remaining three regions. Comparing regional energy consumption and population in 1990, the Baghdad region shows a higher proportion of energy consumption (38 % of total), when compared with the population (24 % of total). This means that energy consumption per capita in the Baghdad region is higher than in the other regions.

Comparing the two sets of data, the regional energy consumption appears to maintain a similar trend, even though the data in 2001 does not include the Erbil and Sulaymaniyah governorates.

The following figure shows regional energy consumption at the consumers' end by categories in 2001.

---

[9] The data in 2001 does not include 3 Northern governorates.



	Baghdad	Middle	North+Dahuk	South	Total
🟩 Agricultural	130	422	264	111	928
🟨 Govermental	1,414	494	683	341	2,931
🟪 Industrial	1,146	1,430	1,939	2,102	6,617
🟧 Commercial	1,004	105	108	104	1,320
☐ Household	5,981	1,837	1,762	1,395	10,976

Data source: WB Needs Assessment of the Electricity Sector of Iraq, Annex E Customer Services Issues; 2003

Figure 6.5-4 Regional Energy Consumption at Consumers' End in 2001[10]

In the Middle, North (+ Dahuk) and South regions, the energy consumption for households and industrial use accounts for 80 % of each regional total. In the Baghdad region, the percentage of the energy consumption from commercial and governmental use is larger than that of the other regions.

(2) Network Losses

Referring to the above energy consumption data at the consumers' end and regional energy data reported by MoE, the regional network losses in 2001 are estimated below.

Table 6.5-5 Regional Energy and Network Losses in 2001[11]

Unit : GWh

Items		Baghdad + Middle	North + Dahuk	South	Total
Regional Energy Total	: (a)	19,965	7,592	5,655	33,213
Regional Energy excl. Aux. consumption & Losses in P/S	: (b)	19,205	6,851	5,020	31,076
Regional Energy at MoE Network (High Voltage) Ends	: (c)	17,397	6,624	4,632	28,653

---

[10] Sulaymaniyah and Erbil are not included in the data.
[11] Sulaymaniyah and Erbil are not included in the data.

Regional Energy at Consumers' Ends	: (d)	13,963	4,756	4,053	22,772
Total Network Loss	: (e)=(d)/(b)	27%	31%	19%	**27%**
High Voltage Network Loss	: (f)=(c)/(b)	9%	3%	8%	**8%**
Low Voltage Network Loss	: (g)=(e)-(f)	18%	27%	12%	**19%**

Data source: (a), (b), (c) from MoE Generation & Energy Balance Report for 2001, and (d) from WB Needs Assessment of the Electricity Sector of Iraq, Annex E Customer Services Issues; 2003

Total network losses in 2001 are estimated at 27 % against P/S sent-out points. High voltage network losses and low voltage network losses account for 8 % and 19 % in total, respectively.

According to the above estimate, total network loss of the South region is the least among the three regions. In the North + Dahuk region, the high voltage network loss is less than the other regions, while the low voltage loss is more than 10 % higher than the other regions.

Incidentally, the high voltage network losses of the Baghdad/Middle, North+Dahuk and South regions in 2002 are also estimated at 8 %, 3 % and 9 %, respectively.

(3) Regional Energy Consumption per Capita

Based on the above energy consumption data and the population data, the energy consumption per capita at the consumers' end in 1990 and 2001 is calculated in Table 6.5-6 and 6.5-7, respectively. The detailed data of Table 6.5-6 is given in Appendix B.6.

Table 6.5-6 Energy Consumption per Capita at Consumers' End in 1990

Region	Population[12] (x 1,000)	Energy Consumption at Consumers' End (GWh)	kWh/capita at Consumers' End (kWh/capita)
Baghdad	4,269	7,910	1,853
Middle	5,408	4,925	911
North	3,055	3,055	1,000
South	2,914	2,570	1,180
3 Northern Gov.	2,244	1,984	884
Total	17,890	20,444	1,143

---

[12] The population in 1990 is estimated from the population by Governorate in 1988 and the annual increase ratio from 1987 to 1997 in Appendix B.2.

Only the consumers in the Baghdad region use more energy than the total average, and the energy consumption per capita of the Baghdad region is twice that of the Middle region. Out of the five regions, the least energy consumption per capita is in the 3 Northern Governorates.

Table 6.5-7 Energy Consumption per Capita at Consumers' End in 2001[13]

Regions	Population[14] (x 1,000)	Energy Consumption at Consumers' End (GWh)	kWh/capita at Consumers' End (kWh/capita)
Baghdad	5,949	9,675	1,626
Middle	6,892	4,288	622
North + Dahuk	4,738	4,756	1,004
South	4,409	4,053	919
Total	21,989	22,772	1,036

Also in 2001, only the energy consumption in the Baghdad region is more than the total average. The difference between energy consumption per capita of the Baghdad and Middle regions has increased from 2 times in 1990 to 2.6 times in 2001. The only region, where energy consumption per capita is increased, is the South region.

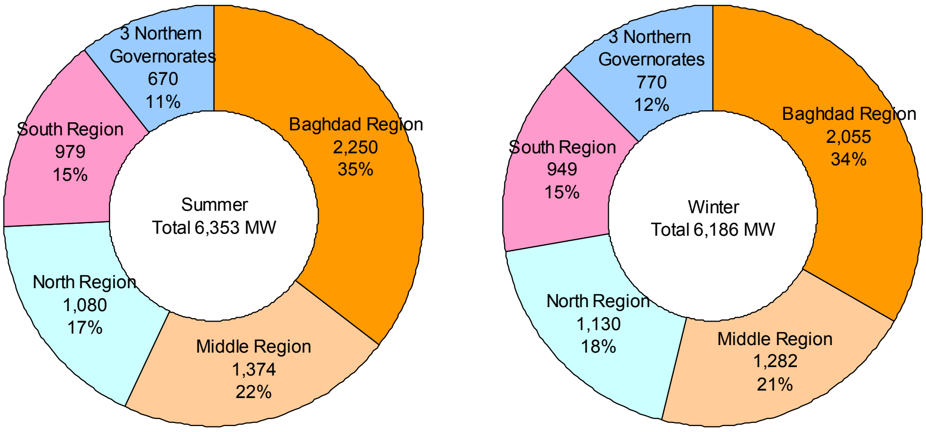
6.5.5 Regional Peak Load

Data for actual regional peak loads before the recent conflict in 2003 has not been available for the Study. However, the UNDP has estimated the regional peak demand in their report (the Observation Brief on the Energy Sector of Iraq; June 2003). Figure 6.5-5 shows the regional peak demand for the summer and winter in 2002 estimated by UNDP. The details are given in Appendix B.9. It is noted that the estimated demand is at the 11 kV distribution feeders' level.

---

[13] Sulaymaniyah and Erbil are not included in the data.

[14] The population in 2001 is estimated from the population by Governorate in 2002 and the annual increase ratio from 1997 to 2003 in Appendix B.2.



Data source: UNDP Observation Brief on the Energy Sector of Iraq; June 2003

Figure 6.5-5 Regional Peak Demand for 2002

In both summer and winter, the peak demand for the Baghdad and Middle regions accounts for around 60 % of the total. Regional distribution of the peak demand is similar to the distribution of the regional energy consumption in 1990 as well as 2001.

Based on the above peak demand and the energy demand estimated by the Team, the regional annual load factors are estimated in the following table. The details are given in Appendix B.10.

Table 6.5-8 Annual Load Factors for Peak Demand Estimated by UNDP

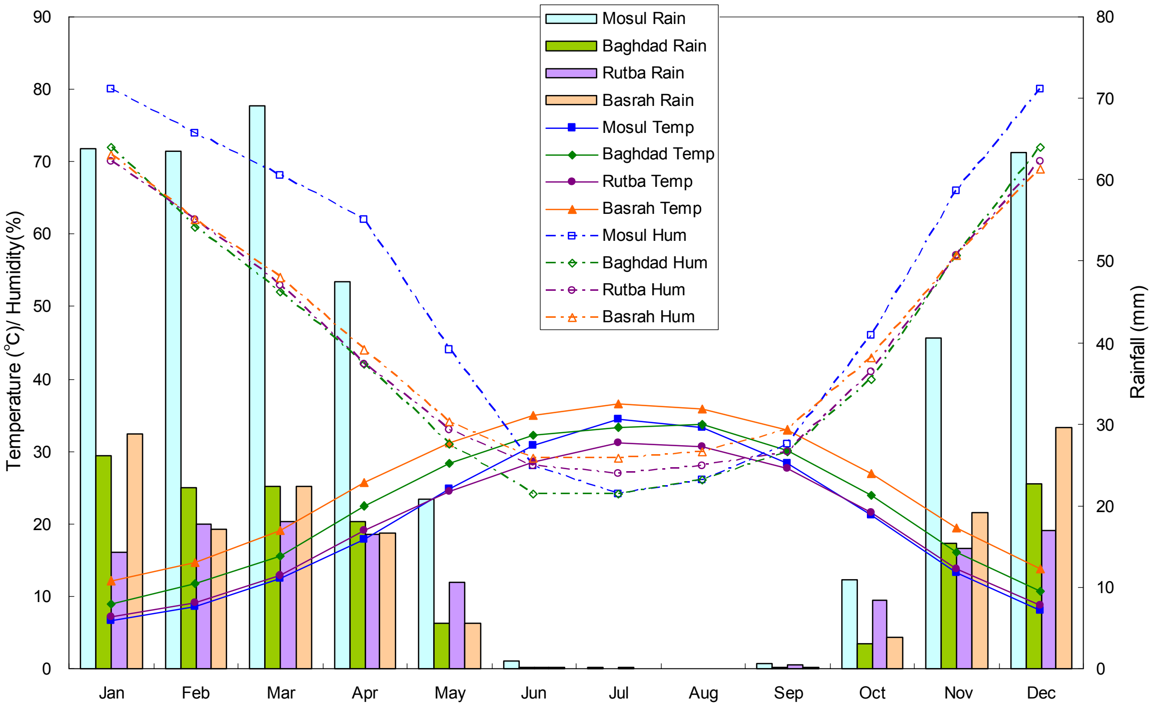
Regions	Estimated Energy Demand for 2002, GWh (by the Team)	Estimated Peak Demand for Summer 2002, MW (by UNDP)	Annual Load Factors for 2002
Baghdad Region	11,217	2,250	70%
Middle Region	6,533	1,374	67%
North Region	4,107	1,080	53%
South Region	4,124	979	59%
3 Northern Governorates	3,258	670	68%
Total	29,239	6,353	65%

It should be noted that the annual load factors in the table are not actual load factors. The load factors have been estimated from the energy demand and the peak demand, which are expected to reflect the unsuppressed conditions, and the estimated 65 % for the total system appears to be a reasonable figure.

6.5.6 Seasonal Energy Consumption and Peak Load

(1) Climate

Figure 6.5-6 shows monthly average temperature, humidity and rainfall in Mosul, Baghdad, Rutba (west of Iraq) and Basrah.



Data source: Funding Seismographic & Meteorological Commission

Figure 6.5-6 Monthly Average Temperature, Humidity and Rainfall[15]

Out of the cities, Basrah is the hottest throughout the year. The temperatures in winter in Mosul are slightly lower than in the others. However, the temperature in summer in Mosul goes up to almost the same level as Baghdad or Basrah. In 2001, the hottest temperature (48.6℃) was recorded in August in Basrah and the lowest one (3℃) occurred in January in Mosul.

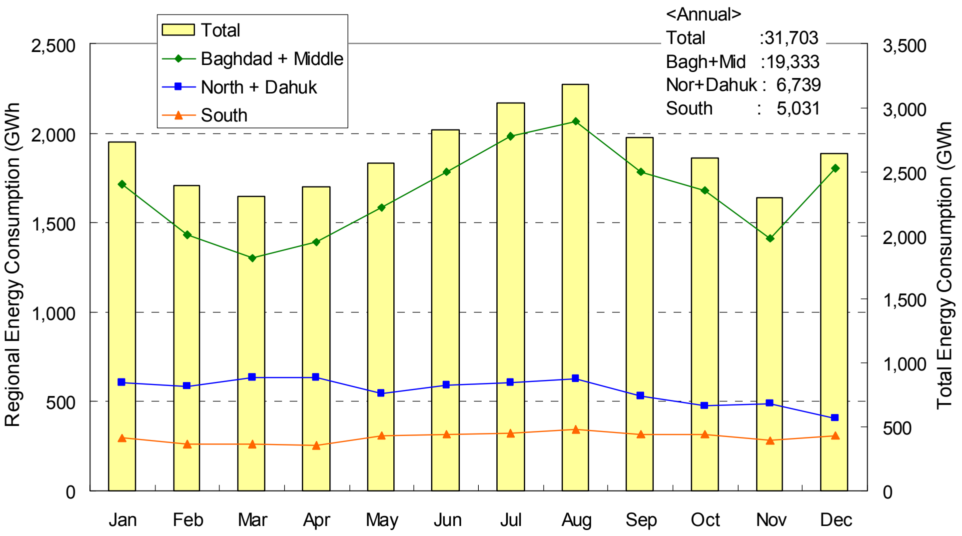
As indicated in the figure, humidity and rainfall changes correspond with each other. Annual average rainfall in Mosul, Baghdad, Rutba and Basrah are 381 mm, 136 mm, 118 mm and 144 mm, respectively. The climate of all the cities is clearly distinguished into the dry season from May to October and the rainy season from November to April, and more than 90 % of the annual rainfall is obtained in the rainy season.

---

[15] Period of the average is 30 years.

(2) Seasonal Energy Consumption and Peak Load by Region

The monthly energy consumption by region in 2002 is illustrated in Figure 6.5-7. It is noted that the energy data is at the end terminals of the MoE network, that is, the data is estimated at the terminals of the high voltage 400 kV and/or 132 kV networks.



Data source: MoE Generation & Energy balance Report for 2002 Jan. ~ Dec.

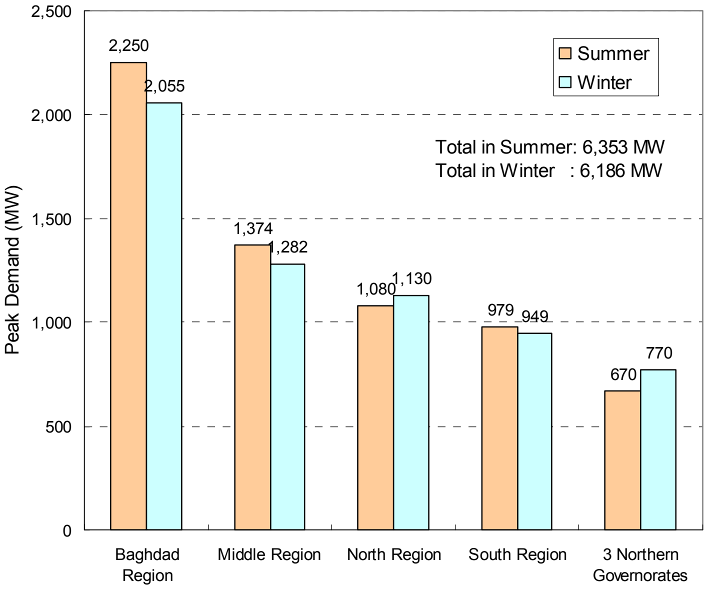
Figure 6.5-7 Monthly Energy Consumption at MoE Network Ends by Region in 2002[16]

The monthly changes in total energy consumption appear to reflect seasonal climate changes such as temperature. In the Baghdad, Middle and South regions, high energy consumption occurs during the summer months of July to August, while energy consumption of the North region in winter is higher than that in summer.

As discussed in Chapter 6.5.5 (Regional Peak Load), the actual regional peak load data before the recent conflict in 2003 has not been available for the Study. Figure 6.5-8 shows the seasonal peak demand estimated by UNDP, which is the same data as Figure 6.5-5.

---

[16] Sulaymaniyah and Erbil are not included in the data.



Data source: UNDP Observation Brief on the Energy Sector of Iraq; June 2003

Figure 6.5-8 Seasonal Peak Demand by Region for 2002

In the Baghdad, Middle and South regions, the peak demand occurs in summer, while the peak demand of the North region and 3 Northern Governorates is higher in winter than in summer. However, the difference between summer and winter is not significant. Considering the climate of Iraq, it is conceivable that the winter demand for heating takes the place of the summer demand for cooling

6.5.7 Assumptions and Procedure for Regional Demand Forecast

(1) Assumptions for Regional Demand Forecast

As generally mentioned in the approach to the regional demand forecast, energy demand per capita, network losses and load factors are assumed as parameters for the forecast.

Regional energy demand per capita in the year 2004, which is the starting year for the forecast, is assumed to be the same as the regional energy consumption in 1990. The assumption refers to the concept of the nation wide demand forecast. After 2004, the energy demand is increased at the rate shown in Table 6.5-9. Those are also the same ratios as used in the nation wide demand forecast.

Table 6.5-9 Annual Increase Ratios for Energy Demand at Consumers' End

Year	Annual Increase Ratios
2004 to 2005	3%
2005 to 2007	6%
2007 to 2010	8%
2010 to 2015	7%
2015 to 2020	6%

It should be noted that the regional increases are not considered in the forecast. If the demand forecast starts from the suppressed demand, the demand may increase at different rates reflecting the current conditions which may differ region by region. However, our forecast starts from the unsuppressed demand, which is assumed to be the same as the demand in 1990, and assumes the regions to be developed with equally balanced rates throughout the period. Accordingly, the regional increases are not considered separately in our forecast.

In addition, the annual increase ratios contain the increases of energy consumption per capita and population as well as electrification ratios.

Regional network losses are assumed using the regional coefficients in the following table, which are derived from the regional network losses in 2001 (refer to Table 6.5-5). That is, the network loss in the North region and the 3 Northern Governorates is set at 1.12 times that of the Baghdad and Middle regions.

Table 6.5-10 Coefficient of Regional Network Loss

Regions	Estimated Total Network Losses in 2001[17]	Coefficient
Baghdad & Middle Region	27%	1.00
North Region & 3 Northern Governorates	31%	1.12
South Region	19%	0.71
Total	27%	-

In order to estimate the demand at 132 kV S/S ends, the Team assumed the low voltage and high voltage network losses as shown below.

---

[17] Refer to Table 6.5-5

Table 6.5-11 Assumed Network Losses[18]

Year	Low Voltage Network Loss (%)	High Voltage Network Loss (%)	Total Network (T/L+D/L) Loss (%)	Remarks
2004	20	13	33	Sort tern period
2005	20	12	32	
2006	19	11	30	
2007	18	10	28	
2008	17.5	9.5	27	Semi-middle term period
2009	17.5	9.5	27	
2010	17	9	26	
2011	16.5	8.5	25	Middle term period
2012	16.5	8.5	25	
2013	16	8	24	
2014	16	8	24	
2015	15	8	23	
2016	14.5	7.5	22	Long term period
2017	14.5	7.5	22	
2018	14	7	21	
2019	14	7	21	
2020	13	7	20	

In the forecast, the characteristics of regional load factors are also considered. The following table shows the assumed coefficient of regional load factors compared with the Baghdad region.

Table 6.5-12 Coefficient of Regional Load Factor

Regions	Estimated Annual Load Factors in 2002[19]	Coefficient
Baghdad Region	70%	1.00
Middle Region	67%	0.95
North Region	53%	0.76
South Region	59%	0.84
3 Northern Governorates	68%	0.98
Total	65%	-

In order to reflect the regional characteristics of electricity use, the regional coefficients derived from the estimated regional load factors in 2002 are utilized for the assumptions even though such assumptions need to reflect the regional

---

[18] Percentages are against annual sent-out energy of power stations.

[19] Refer to Table 6.5-8

development policies or plans by categories. It is recommended that the regional load factors be reviewed at a time when future regional patterns become clearer.

In addition, it is noted that the diversity factor is not considered for the peak demand in our forecast because the relevant data has not been available. That is, an aggregate sum of the regional peak demands is simply dealt with as the peak demand for the total Iraq.

(2) Procedure for Regional Demand Forecast

The steps in the regional demand forecast are as follows:

i) Calculate the energy demand at the consumers' end based on the assumed annual increases which are used in the nation wide demand forecast (refer to Table 6.5-9);

ii) Calculate the peak demand at the consumers' end based on the assumed regional load factor (to be calculated using the coefficient in Table 6.5-12);

iii) Calculate the energy demand at the 132 kV S/S ends based on the assumed regional network losses; and

iv) Calculate the peak demand at 132 kV S/S ends based on the assumed regional load factor.

It is also noted that the regional load factors at the consumers' end and 132 kV S/S end are set as the same value. Load factors at the both ends should be similar even though there may be some time difference.

Moreover, the peak load in the winter season has not been forecast. The peak demand in this Study is estimated for maximum total peak demand through the year, i.e., the peak demand in the summer season. Considering the seasonal characteristics of peak demand, the peak demand in the summer season is more critical for the whole power system than that in the winter season. Even though the peak demand in the North region and 3 Northern Governorates might be higher in winter than in summer (refer to Figure 6.5-8), the differences seem to be negligible for the demand forecast at a general master plan level.

6.5.8 Result of Regional Demand Forecast

Based on the above assumptions and procedure, energy and peak demand by governorates have been calculated. Results of the calculation from 2004 to 2020 are shown in the following tables.

It is noted that the demands have been calculated at both of the consumers' end and the 132 kV S/S end.

Table 6.5-13 Energy Demand at Consumers' End

Governorate & Region / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Baghdad Region																	
Rasafa & Suburbs																	
Karkh & Suburbs																	
Baghdad Region	**11,429**	**11,772**	**12,478**	**13,227**	**14,285**	**15,428**	**16,662**	**17,829**	**19,077**	**20,412**	**21,841**	**23,370**	**24,772**	**26,258**	**27,834**	**29,504**	**31,274**
Middle Region																	
Diyala	998	1,028	1,090	1,155	1,248	1,347	1,455	1,557	1,666	1,783	1,907	2,041	2,163	2,293	2,431	2,577	2,731
Anbar	1,362	1,403	1,487	1,576	1,702	1,838	1,985	2,124	2,273	2,432	2,602	2,785	2,952	3,129	3,317	3,516	3,726
Najaf	1,029	1,060	1,123	1,190	1,286	1,389	1,500	1,605	1,717	1,837	1,966	2,103	2,230	2,363	2,505	2,655	2,815
Kerbela	679	699	741	785	848	916	989	1,059	1,133	1,212	1,297	1,388	1,471	1,559	1,653	1,752	1,857
Qaddisiya	903	930	986	1,045	1,129	1,219	1,316	1,408	1,507	1,613	1,725	1,846	1,957	2,074	2,199	2,331	2,471
Wasit	1,074	1,107	1,173	1,243	1,343	1,450	1,566	1,676	1,793	1,919	2,053	2,197	2,329	2,468	2,617	2,774	2,940
Babylon	910	938	994	1,054	1,138	1,229	1,327	1,420	1,519	1,626	1,740	1,861	1,973	2,092	2,217	2,350	2,491
Total Middle Region	**6,955**	**7,164**	**7,593**	**8,049**	**8,693**	**9,388**	**10,139**	**10,849**	**11,609**	**12,421**	**13,291**	**14,221**	**15,074**	**15,979**	**16,937**	**17,954**	**19,031**
North Region																	
Al-Tameem	835	860	911	966	1,043	1,127	1,217	1,302	1,393	1,491	1,595	1,707	1,809	1,918	2,033	2,155	2,284
Salah-Al-Din	1,095	1,127	1,195	1,267	1,368	1,477	1,596	1,707	1,827	1,955	2,092	2,238	2,372	2,515	2,666	2,825	2,995
Ninewa	2,417	2,490	2,639	2,797	3,021	3,263	3,524	3,771	4,035	4,317	4,619	4,943	5,239	5,553	5,887	6,240	6,614
Total North Region	**4,346**	**4,477**	**4,745**	**5,030**	**5,433**	**5,867**	**6,337**	**6,780**	**7,255**	**7,762**	**8,306**	**8,887**	**9,421**	**9,986**	**10,585**	**11,220**	**11,893**
South Region																	
Basra	2,296	2,365	2,507	2,658	2,870	3,100	3,348	3,582	3,833	4,101	4,388	4,696	4,977	5,276	5,593	5,928	6,284
Muthanna	440	453	481	510	550	594	642	687	735	786	841	900	954	1,012	1,072	1,137	1,205
Thi Qar	924	952	1,009	1,069	1,155	1,247	1,347	1,441	1,542	1,650	1,766	1,889	2,003	2,123	2,250	2,385	2,529
Missan	700	721	764	810	874	944	1,020	1,091	1,168	1,250	1,337	1,431	1,516	1,607	1,704	1,806	1,914
Total South Region	**4,360**	**4,491**	**4,761**	**5,046**	**5,450**	**5,886**	**6,357**	**6,802**	**7,278**	**7,787**	**8,333**	**8,916**	**9,451**	**10,018**	**10,619**	**11,256**	**11,931**
Total the above reqions	**27,091**	**27,904**	**29,578**	**31,353**	**33,861**	**36,570**	**39,495**	**42,260**	**45,218**	**48,383**	**51,770**	**55,394**	**58,718**	**62,241**	**65,975**	**69,934**	**74,130**
3 Northern Governorates																	
Sulaymaniyah	1,027	1,057	1,121	1,188	1,283	1,386	1,497	1,601	1,713	1,833	1,962	2,099	2,225	2,358	2,500	2,650	2,809
Erbil	1,549	1,596	1,692	1,793	1,937	2,092	2,259	2,417	2,586	2,767	2,961	3,168	3,358	3,560	3,773	4,000	4,240
Dohuk	811	835	885	939	1,014	1,095	1,182	1,265	1,354	1,448	1,550	1,658	1,758	1,863	1,975	2,094	2,219
Total 3 Northern Governorates	**3,387**	**3,489**	**3,698**	**3,920**	**4,233**	**4,572**	**4,938**	**5,283**	**5,653**	**6,049**	**6,472**	**6,926**	**7,341**	**7,782**	**8,248**	**8,743**	**9,268**
Grand Total	**30,478**	**31,392**	**33,276**	**35,272**	**38,094**	**41,142**	**44,433**	**47,543**	**50,871**	**54,432**	**58,243**	**62,320**	**66,059**	**70,022**	**74,224**	**78,677**	**83,398**

Table 6.5-14 Peak Demand at Consumers' End

Governorate & Region / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Baghdad Region	*(81%)*	*(81%)*	*(78%)*	*(78%)*	*(76%)*	*(76%)*	*(76%)*	*(75%)*	*(74%)*	*(73%)*	*(72%)*	*(71%)*	*(72%)*	*(73%)*	*(74%)*	*(75%)*	*(76%)*
Rasafa & Suburbs																	
Karkh & Suburbs																	
Baghdad Region	**1,605**	**1,653**	**1,824**	**1,933**	**2,149**	**2,320**	**2,506**	**2,721**	**2,955**	**3,205**	**3,482**	**3,784**	**3,950**	**4,123**	**4,311**	**4,503**	**4,704**
Middle Region	*(78%)*	*(78%)*	*(75%)*	*(75%)*	*(72%)*	*(72%)*	*(72%)*	*(71%)*	*(70%)*	*(69%)*	*(68%)*	*(67%)*	*(68%)*	*(69%)*	*(70%)*	*(71%)*	*(72%)*
Diyala	147	151	167	177	197	212	229	249	270	293	319	346	361	377	395	412	431
Anbar	200	206	228	241	268	290	313	340	369	400	435	473	493	515	538	562	587
Najaf	151	156	172	182	203	219	236	257	279	302	328	357	373	389	407	425	444
Kerbela	100	103	114	120	134	144	156	169	184	199	217	235	246	257	268	280	293
Qaddisiya	133	137	151	160	178	192	207	225	245	265	288	313	327	341	357	373	389
Wasit	158	163	180	190	212	229	247	268	291	316	343	373	389	406	425	444	463
Babylon	134	138	152	161	179	194	209	227	247	268	291	316	330	344	360	376	393
Total Middle Region	**1,024**	**1,054**	**1,163**	**1,233**	**1,370**	**1,480**	**1,598**	**1,735**	**1,885**	**2,044**	**2,221**	**2,413**	**2,519**	**2,630**	**2,750**	**2,872**	**3,000**
North Region	*(62%)*	*(62%)*	*(60%)*	*(60%)*	*(58%)*	*(58%)*	*(58%)*	*(57%)*	*(56%)*	*(55%)*	*(55%)*	*(54%)*	*(55%)*	*(55%)*	*(56%)*	*(57%)*	*(58%)*
Al-Tameem	154	158	175	185	206	222	240	261	283	307	333	362	378	395	413	431	450
Salah-Al-Din	201	208	229	243	270	291	315	342	371	402	437	475	496	518	541	565	591
Ninewa	445	458	506	536	596	643	695	754	819	889	966	1,049	1,095	1,143	1,195	1,249	1,304
Total North Region	**800**	**824**	**909**	**964**	**1,071**	**1,157**	**1,249**	**1,357**	**1,473**	**1,598**	**1,736**	**1,887**	**1,969**	**2,056**	**2,150**	**2,245**	**2,345**
South Region	*(69%)*	*(69%)*	*(66%)*	*(66%)*	*(64%)*	*(64%)*	*(64%)*	*(63%)*	*(62%)*	*(61%)*	*(60%)*	*(60%)*	*(60%)*	*(61%)*	*(62%)*	*(63%)*	*(64%)*
Basra	382	393	434	460	511	552	596	647	703	762	828	900	939	981	1,025	1,071	1,119
Muthanna	73	75	83	88	98	106	114	124	135	146	159	173	180	188	197	205	214
Thi Qar	154	158	175	185	206	222	240	260	283	307	333	362	378	395	413	431	450
Missan	116	120	132	140	156	168	182	197	214	232	252	274	286	299	312	326	341
Total South Region	**725**	**746**	**824**	**873**	**970**	**1,048**	**1,132**	**1,229**	**1,334**	**1,447**	**1,572**	**1,709**	**1,783**	**1,862**	**1,947**	**2,033**	**2,124**
Total the above reqions	**4,153**	**4,278**	**4,720**	**5,003**	**5,560**	**6,005**	**6,485**	**7,042**	**7,647**	**8,295**	**9,012**	**9,793**	**10,221**	**10,670**	**11,157**	**11,653**	**12,173**
3 Northern Governorates	*(79%)*	*(79%)*	*(76%)*	*(76%)*	*(74%)*	*(74%)*	*(74%)*	*(73%)*	*(72%)*	*(71%)*	*(70%)*	*(69%)*	*(70%)*	*(71%)*	*(72%)*	*(73%)*	*(74%)*
Sulaymaniyah	148	152	168	178	198	214	231	251	272	295	321	348	364	380	397	415	433
Erbil	223	230	254	269	299	323	348	378	411	445	484	526	549	573	599	626	654
Dohuk	117	120	133	141	156	169	182	198	215	233	253	275	287	300	314	328	342
Total 3 Northern Governorates	**488**	**502**	**554**	**587**	**653**	**705**	**761**	**827**	**898**	**974**	**1,058**	**1,150**	**1,200**	**1,253**	**1,310**	**1,368**	**1,429**
Grand Total	**4,641** *(75%)*	**4,780** *(75%)*	**5,274** *(72%)*	**5,591** *(72%)*	**6,213** *(70%)*	**6,710** *(70%)*	**7,247** *(70%)*	**7,868** *(69%)*	**8,545** *(68%)*	**9,269** *(67%)*	**10,070** *(66%)*	**10,943** *(65%)*	**11,421** *(66%)*	**11,923** *(67%)*	**12,467** *(68%)*	**13,021** *(69%)*	**13,602** *(70%)*

Note: % = Load Factor

Table 6.5-15 Energy Demand at 132 kV S/S Terminals

Governorate & Region / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Baghdad Region	*(18%)*	*(18%)*	*(17%)*	*(16%)*	*(16%)*	*(16%)*	*(16%)*	*(15%)*	*(15%)*	*(15%)*	*(15%)*	*(14%)*	*(13%)*	*(13%)*	*(13%)*	*(13%)*	*(12%)*
Rasafa & Suburbs																	
Karkh & Suburbs																	
Baghdad Region	**14,539**	**14,928**	**15,571**	**16,248**	**17,425**	**18,819**	**20,162**	**21,428**	**22,928**	**24,344**	**26,048**	**27,539**	**29,007**	**30,747**	**32,355**	**34,296**	**35,938**
Middle Region	*(18%)*	*(18%)*	*(17%)*	*(16%)*	*(16%)*	*(16%)*	*(16%)*	*(15%)*	*(15%)*	*(15%)*	*(15%)*	*(14%)*	*(13%)*	*(13%)*	*(13%)*	*(13%)*	*(12%)*
Diyala	1,270	1,304	1,360	1,419	1,522	1,643	1,761	1,871	2,002	2,126	2,275	2,405	2,533	2,685	2,825	2,995	3,138
Anbar	1,732	1,779	1,855	1,936	2,076	2,242	2,402	2,553	2,732	2,901	3,104	3,281	3,456	3,664	3,855	4,087	4,282
Najaf	1,309	1,344	1,401	1,462	1,568	1,694	1,815	1,929	2,064	2,191	2,344	2,479	2,611	2,767	2,912	3,087	3,235
Kerbela	863	886	925	965	1,035	1,117	1,197	1,272	1,361	1,445	1,547	1,635	1,722	1,826	1,921	2,036	2,134
Qaddisiya	1,149	1,179	1,230	1,284	1,377	1,487	1,593	1,693	1,811	1,923	2,058	2,176	2,292	2,429	2,556	2,709	2,839
Wasit	1,367	1,403	1,464	1,527	1,638	1,769	1,895	2,014	2,155	2,288	2,449	2,589	2,727	2,890	3,042	3,224	3,378
Babylon	1,158	1,189	1,240	1,294	1,388	1,499	1,606	1,707	1,826	1,939	2,075	2,193	2,310	2,449	2,577	2,732	2,862
Total Middle Region	**8,847**	**9,084**	**9,475**	**9,887**	**10,603**	**11,452**	**12,269**	**13,039**	**13,952**	**14,814**	**15,851**	**16,758**	**17,651**	**18,710**	**19,689**	**20,870**	**21,869**
North Region	*(28%)*	*(28%)*	*(26%)*	*(25%)*	*(24%)*	*(24%)*	*(24%)*	*(23%)*	*(23%)*	*(22%)*	*(22%)*	*(21%)*	*(20%)*	*(20%)*	*(20%)*	*(20%)*	*(18%)*
Al-Tameem	1,203	1,232	1,275	1,319	1,409	1,522	1,624	1,720	1,840	1,946	2,082	2,189	2,298	2,435	2,553	2,706	2,820
Salah-Al-Din	1,577	1,616	1,672	1,730	1,848	1,996	2,130	2,255	2,413	2,552	2,731	2,870	3,013	3,194	3,348	3,549	3,698
Ninewa	3,484	3,569	3,691	3,820	4,082	4,408	4,703	4,981	5,329	5,636	6,030	6,338	6,654	7,053	7,394	7,837	8,166
Total North Region	**6,264**	**6,417**	**6,638**	**6,869**	**7,339**	**7,926**	**8,457**	**8,956**	**9,583**	**10,134**	**10,843**	**11,396**	**11,964**	**12,682**	**13,295**	**14,093**	**14,683**
South Region	*(12%)*	*(12%)*	*(11%)*	*(11%)*	*(10%)*	*(10%)*	*(10%)*	*(10%)*	*(10%)*	*(9%)*	*(9%)*	*(9%)*	*(9%)*	*(9%)*	*(8%)*	*(8%)*	*(8%)*
Basra	2,648	2,724	2,863	3,008	3,237	3,496	3,758	4,006	4,287	4,567	4,887	5,192	5,483	5,812	6,135	6,503	6,846
Muthanna	508	522	549	577	621	670	721	768	822	876	937	995	1,051	1,114	1,176	1,247	1,313
Thi Qar	1,066	1,096	1,152	1,211	1,302	1,407	1,512	1,612	1,725	1,838	1,966	2,089	2,206	2,339	2,469	2,617	2,755
Missan	807	830	872	917	986	1,065	1,145	1,221	1,306	1,391	1,489	1,582	1,671	1,771	1,869	1,981	2,086
Total South Region	**5,028**	**5,173**	**5,436**	**5,712**	**6,146**	**6,637**	**7,136**	**7,607**	**8,140**	**8,671**	**9,278**	**9,858**	**10,412**	**11,036**	**11,649**	**12,348**	**12,999**
Total the above reqions	**34,677**	**35,601**	**37,120**	**38,718**	**41,513**	**44,834**	**48,024**	**51,030**	**54,602**	**57,963**	**62,020**	**65,550**	**69,034**	**73,176**	**76,988**	**81,607**	**85,489**
3 Northern Governorates	*(28%)*	*(28%)*	*(26%)*	*(25%)*	*(24%)*	*(24%)*	*(24%)*	*(23%)*	*(23%)*	*(22%)*	*(22%)*	*(21%)*	*(20%)*	*(20%)*	*(20%)*	*(20%)*	*(18%)*
Sulaymaniyah	1,479	1,516	1,568	1,622	1,733	1,872	1,997	2,115	2,263	2,393	2,561	2,692	2,826	2,995	3,140	3,328	3,468
Erbil	2,233	2,288	2,366	2,449	2,616	2,826	3,015	3,193	3,416	3,613	3,865	4,063	4,265	4,521	4,739	5,024	5,234
Dohuk	1,169	1,197	1,239	1,282	1,369	1,479	1,578	1,671	1,788	1,891	2,023	2,127	2,232	2,366	2,481	2,630	2,740
Total 3 Northern Governorates	**4,881**	**5,001**	**5,173**	**5,353**	**5,719**	**6,177**	**6,590**	**6,979**	**7,467**	**7,897**	**8,450**	**8,881**	**9,323**	**9,882**	**10,360**	**10,982**	**11,442**
Grand Total	**39,559**	**40,602**	**42,292**	**44,071**	**47,232**	**51,011**	**54,614**	**58,009**	**62,070**	**65,860**	**70,470**	**74,431**	**78,357**	**83,058**	**87,348**	**92,589**	**96,931**
	(20%)	*(20%)*	*(19%)*	*(18%)*	*(18%)*	*(18%)*	*(17%)*	*(17%)*	*(17%)*	*(16%)*	*(16%)*	*(15%)*	*(15%)*	*(15%)*	*(14%)*	*(14%)*	*(13%)*

Note: % = Low Voltage Network Loss Ratio

Table 6.5-16 Peak Demand at 132 kV S/S Terminals

Governorate & Region / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Baghdad Region	*(81%)*	*(81%)*	*(78%)*	*(78%)*	*(76%)*	*(76%)*	*(76%)*	*(75%)*	*(74%)*	*(73%)*	*(72%)*	*(71%)*	*(72%)*	*(73%)*	*(74%)*	*(75%)*	*(76%)*
Rasafa & Suburbs																	
Karkh & Suburbs																	
Baghdad Region	**2,041**	**2,096**	**2,276**	**2,375**	**2,621**	**2,830**	**3,032**	**3,270**	**3,551**	**3,823**	**4,153**	**4,459**	**4,625**	**4,828**	**5,012**	**5,234**	**5,405**
Middle Region	*(78%)*	*(78%)*	*(75%)*	*(75%)*	*(72%)*	*(72%)*	*(72%)*	*(71%)*	*(70%)*	*(69%)*	*(68%)*	*(67%)*	*(68%)*	*(69%)*	*(70%)*	*(71%)*	*(72%)*
Diyala	187	192	208	217	240	259	278	299	325	350	380	408	423	442	459	479	495
Anbar	255	262	284	297	327	353	379	408	444	477	519	557	578	603	626	654	675
Najaf	193	198	215	224	247	267	286	308	335	361	392	421	436	455	473	494	510
Kerbela	127	130	142	148	163	176	189	204	221	238	258	278	288	300	312	326	336
Qaddisiya	169	174	188	197	217	234	251	271	294	316	344	369	383	400	415	433	448
Wasit	201	207	224	234	258	279	299	322	350	377	409	439	456	476	494	516	533
Babylon	170	175	190	198	219	236	253	273	296	319	347	372	386	403	418	437	451
Total Middle Region	**1,302**	**1,337**	**1,452**	**1,515**	**1,671**	**1,805**	**1,934**	**2,086**	**2,265**	**2,438**	**2,649**	**2,844**	**2,950**	**3,079**	**3,196**	**3,338**	**3,447**
North Region	*(62%)*	*(62%)*	*(60%)*	*(60%)*	*(58%)*	*(58%)*	*(58%)*	*(57%)*	*(56%)*	*(55%)*	*(55%)*	*(54%)*	*(55%)*	*(55%)*	*(56%)*	*(57%)*	*(58%)*
Al-Tameem	221	227	244	253	278	300	320	344	374	401	435	465	480	501	518	542	556
Salah-Al-Din	290	297	320	331	364	394	420	451	490	525	571	609	630	657	680	710	729
Ninewa	641	657	707	732	805	869	927	997	1,082	1,160	1,261	1,346	1,391	1,452	1,501	1,568	1,610
Total North Region	**1,153**	**1,181**	**1,272**	**1,316**	**1,447**	**1,563**	**1,668**	**1,792**	**1,946**	**2,086**	**2,267**	**2,419**	**2,501**	**2,611**	**2,700**	**2,820**	**2,895**
South Region	*(69%)*	*(69%)*	*(66%)*	*(66%)*	*(64%)*	*(64%)*	*(64%)*	*(63%)*	*(62%)*	*(61%)*	*(60%)*	*(60%)*	*(60%)*	*(61%)*	*(62%)*	*(63%)*	*(64%)*
Basra	440	453	495	520	576	622	669	724	786	849	922	995	1,035	1,080	1,125	1,175	1,219
Muthanna	84	87	95	100	110	119	128	139	151	163	177	191	198	207	216	225	234
Thi Qar	177	182	199	209	232	250	269	291	316	342	371	400	416	435	453	473	490
Missan	134	138	151	159	176	190	204	220	239	259	281	303	315	329	343	358	371
Total South Region	**836**	**860**	**940**	**988**	**1,094**	**1,182**	**1,270**	**1,374**	**1,492**	**1,612**	**1,751**	**1,889**	**1,965**	**2,051**	**2,136**	**2,231**	**2,314**
Total the above reqions	**5,332**	**5,474**	**5,940**	**6,194**	**6,833**	**7,380**	**7,904**	**8,522**	**9,255**	**9,958**	**10,819**	**11,612**	**12,040**	**12,569**	**13,043**	**13,623**	**14,062**
3 Northern Governorates	*(79%)*	*(79%)*	*(76%)*	*(76%)*	*(74%)*	*(74%)*	*(74%)*	*(73%)*	*(72%)*	*(71%)*	*(70%)*	*(69%)*	*(70%)*	*(71%)*	*(72%)*	*(73%)*	*(74%)*
Sulaymaniyah	213	218	235	243	267	289	308	331	359	385	419	447	462	482	499	521	535
Erbil	321	329	355	367	403	436	465	500	542	582	632	674	697	728	753	786	807
Dohuk	168	172	186	192	211	228	243	261	284	304	331	353	365	381	394	411	422
Total 3 Northern Governorates	**703**	**720**	**775**	**802**	**882**	**952**	**1,016**	**1,092**	**1,186**	**1,271**	**1,381**	**1,474**	**1,524**	**1,591**	**1,645**	**1,718**	**1,764**
Grand Total	**6,035** *(75%)*	**6,194** *(75%)*	**6,715** *(72%)*	**6,997** *(72%)*	**7,715** *(70%)*	**8,333** *(70%)*	**8,921** *(70%)*	**9,614** *(69%)*	**10,440** *(68%)*	**11,230** *(67%)*	**12,200** *(66%)*	**13,086** *(65%)*	**13,564** *(66%)*	**14,160** *(67%)*	**14,689** *(68%)*	**15,341** *(69%)*	**15,826** *(70%)*

Note: % = Load Factor

6.6 Results of Demand Forecast

As a result of the nation wide demand forecast in Chapter 6.4 and the regional demand forecast in Chapter 6.5, the forecast demands for 2004 to 2007, 2010, 2015 and 2020 are summarized below. The detailed calculation results (energy and peak demand at consumers' end, 132 kV S/S end and P/S sent-out points from 2004 to 2020) are given in Appendix B.12.

As mentioned in Chapter 6.1(General Flow) and Chapter 6.5.7 (Assumptions and Procedure for Regional Demand Forecast), the nation wide forecast and the regional forecast are made so that there is no significant different result between the two forecasts. Consequently, result of the regional demand forecast is selected as the forecast demand in the Study.

Table 6.6-1 Energy Demand at Consumers' End

Unit : GWh

Year/ Regions	Baghdad Region	Middle Region	North Region	South Region	3 Northern Governorates	Total
2004	11,429	6,955	4,346	4,360	3,387	3,0478
2005	11,772	7,164	4,477	4,491	3,489	31,392
2006	12,478	7,593	4,745	4,761	3,698	33,276
2007	13,227	8,049	5,030	5,046	3,920	35,272
2010	16,662	10,139	6,337	6,357	4,938	44,433
2015	23,370	14,221	8,887	8,916	6,926	62,320
2020	31,274	19,031	11,893	11,931	9,268	83,398

Table 6.6-2 Peak Demand at Consumers' End

Unit : MW

Year/ Regions	Baghdad Region	Middle Region	North Region	South Region	3 Northern Governorates	Total
2004	1,611	1,027	803	727	489	4,658
2005	1,659	1,058	827	749	504	4,798
2006	1,826	1,165	911	825	555	5,281
2007	1,936	1,235	965	874	588	5,598
2010	2,503	1,596	1,248	1,130	760	7,237
2015	3,811	2,431	1,900	1,721	1,158	11,021
2020	4,698	2,996	2,342	2,121	1,427	13,584

Table 6.6-3 Energy Demand at 132 kV S/S End

Unit : GWh

Year/ Regions	Baghdad Region	Middle Region	North Region	South Region	3 Northern Governorates	Total
2004	14,500	8,823	6,239	5,020	4,862	39,445
2005	14,888	9,060	6,393	5,164	4,982	40,487
2006	15,509	9,437	6,599	5,423	5,142	42,110
2007	16,167	9,838	6,819	5,695	5,313	43,831
2010	20,265	12,332	8,518	7,160	6,638	54,913
2015	27,619	16,807	11,444	9,877	8,918	74,663
2020	35,965	21,886	14,698	13,006	11,454	97,009

Table 6.6-4 Peak Demand at 132 kV S/S End

Unit : MW

Year/ Regions	Baghdad Region	Middle Region	North Region	South Region	3 Northern Governorates	Total
2004	2,043	1,303	1,153	837	703	6,040
2005	2,098	1,338	1,181	861	720	6,199
2006	2,270	1,448	1,266	939	772	6,694
2007	2,366	1,509	1,308	987	797	6,967
2010	3,044	1,941	1,677	1,273	1,022	8,958
2015	4,504	2,873	2,447	1,906	1,491	13,221
2020	5,402	3,445	2,895	2,312	1,764	15,818

Table 6.6-5 Energy Demand at P/S Sent-out Points

Unit : GWh

Year/ Regions	Baghdad Region	Middle Region	North Region	South Region	3 Northern Governorates	Total
2004	17,059	10,380	6,896	5,685	5,374	45,393
2005	17,312	10,535	6,979	5,802	5,438	46,065
2006	17,826	10,848	7,148	6,040	5,570	47,431
2007	18,371	11,179	7,329	6,289	5,711	48,880
2010	22,517	13,702	8,941	7,786	6,967	59,913
2015	30,351	18,469	11,972	10,644	9,330	80,765
2020	39,093	23,789	15,328	13,893	11,944	104,046

Table 6.6-6 Peak Demand at P/S Sent-out Points

Unit : MW

Year/ Regions	Baghdad Region	Middle Region	North Region	South Region	3 Northern Governorates	Total
2004	2,404	1,533	1,274	948	776	6,936
2005	2,440	1,556	1,289	968	786	7,039
2006	2,609	1,664	1,372	1,046	836	7,526
2007	2,689	1,715	1,406	1,089	857	7,756
2010	3,382	2,157	1,761	1,384	1,073	9,757
2015	4,950	3,157	2,560	2,054	1,560	14,280
2020	5,872	3,745	3,018	2,470	1,839	16,945

In addition, the forecast demands for the whole of Iraq for the years 2004 to 2020 are illustrated below.

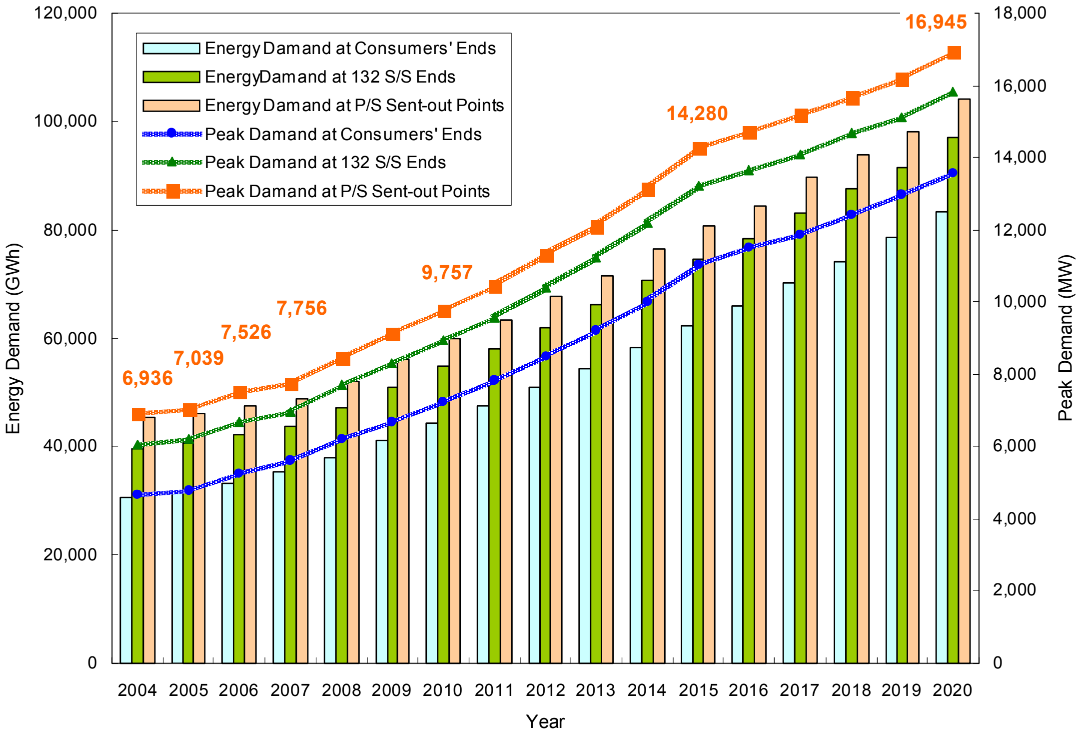
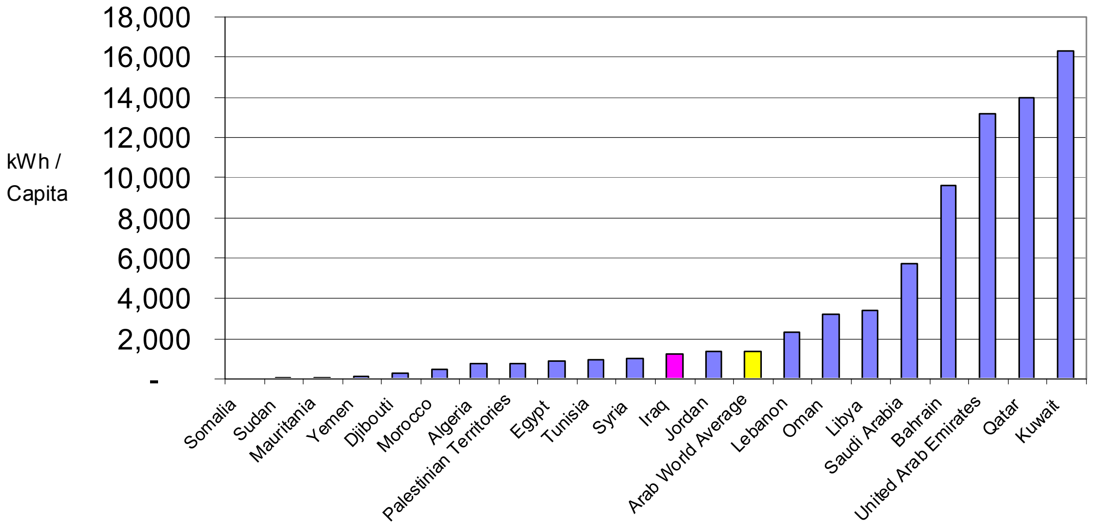


Figure 6.6-1 Total Energy and Peak Demand 2004 to 2020

The energy production (produced energy at P/S generating points) per capita in the neighboring countries is shown in Figure 6.6-2.



Source: WB Needs Assessment of the Electricity Sector of Iraq, Annex E Customer Services Issues; 2003

Figure 6.6-2 Produced Energy per Capita in Neighboring Countries

In the case that the population of Iraq continuously increases at a constant rate of 3 % after 2004, the future energy demand per capita at P/S sent-out points can be calculated from the estimated population and the forecast demand as shown in the following table.

Table 6.6-7 Annual Energy Demand per Capita at P/S Sent-out Points

Year	Estimated Population[20] (x 1,000)	Energy Demand (GWh)	Energy Demand per Capita (kWh/capita)
2010	31,932	59,913	1,876
2015	37,137	80,765	2,175
2020	43,220	104,046	2,407

Considering in-house consumption and losses/meter reading errors in the power station of around 6 % of the energy production, the energy demand per capita of Iraq will reach the level of Lebanon in 2010 and that of Oman or Libya in 2020.

---

[20] 3 % as the annual increase ratio is assumed as a fixed rate for the estimate.

CHAPTER 7 TECHNOLOGY DEVELOPMENT IN ELECTRICITY SECTOR

7.1 General

There are several options for generating sources of electrical energy in Iraq, being blessed with various natural resources. In order to make the development of new power generating facilities technically sound and economically viable and to operate the electricity system in a sustainable manner, various factors should be considered in a comprehensive way. It is recommended that more stress be paid to environmental aspects and efficient use of energy, especially when electricity development is made in collaboration with other countries and under international standards.

To date the electricity energy has been mainly produced by steam plant, gas turbines and hydropower plant. It is necessary to review the development of new thermal plants in line with a national policy on oil and gas which are national strategic products. On the other hand, new types of energy, such as combined cycle plant or renewable energy such as solar energy and wind energy in addition to hydropower can be considered as promising candidates under a growing global concern on sustainable development and environmental conservation.

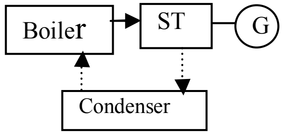
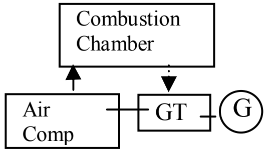
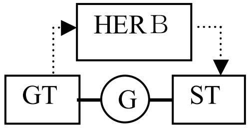
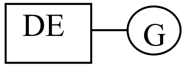
The following sections describe some technical issues to be considered for development of new power generating sources.

7.2 Specific Features of Thermal Plant

Several specific features of conventional thermal plant are described hereinafter, although they are commonly known among the engineers and parties concerned.

First of all, several types of thermal plant are compared generally as shown in Table 7.2-1. The other important features to be noted for thermal plant in Iraq are as follows.

Table 7.2-1 Comparison of Thermal Plant by Types

	Steam Turbine Power Generation	Gas Turbine Power Generation(Simple Cycle)	Combined Cycle Power Generation	Diesel Power Generation
System Structure			 EHRB: Exhausted Heat Recovery Boiler *There are two types of single shaft type(above fig.) and multi shaft type.	
Power Generating Principle	Steam turbine is driven by the steam generated by Boiler.	Gas turbine is driven by hot gas generated in the combustion chamber where fuel is burnt with compressed air.	Combination of Gas turbine and Steam turbine generation. Exhausted gas from gas turbine generates steam in EHRB for steam turbine	Diesel engine drives generator.
Maximum capacity	～1､200MW	～300MW	～1,000MW	～20MW
Thermal efficiency （%）	18～35	16～38	45～58	30～42
Usable fuel	Coal, liquid and gas fuel	Crude oil, fuel oil, LPG, natural gas	Same as left	Diesel Oil
Installation cost as indicative figure	～1,000US$／k W	～700US$／k W	～1,000US$／k W	～500US$／kW
Operation and role in system	Large scale: Base load Middle scale: Daily Start and Stop	Suitable for peak load owing to rapid start and stop time..	Flexible to meet changing load. owing to rapid start-stop time and selection of operating unit number..	Mainly for independent or emergency purpose power generation
Recent trend and features	Conventional system. In case of gas fuel, combined cycle power generation is widely adopted..	Remarkable progress in material to meet higher gas temperature.(Gas inlet temp. 1,500 ℃ is achieved). It will increase thermal efficiency.	This system is main trend in case of mew installation of power generation. High thermal efficiency is attractive.	Advantage in fuel cost (unit cost and relatively high thermal efficiency)
Maintenance issue	Due to higher temperature and higher pressure of Boiler., reliability of maintenance work is important.	Inspection and maintenance interval shall be shortened for frequent start-stop operation. (Base maintenance interval is normally 20,000～24,000 hours)	Same as left.	Maintenance interval is generally short.(3,000 ～ 4,000 hours)

7.2.1 Fuel for Gas Turbines

Regarding gas turbine plant, the components such as gas turbine nozzles, buckets and combustion chambers, etc. are subjected to combustion gas from various fuels. This is a specific factor for gas turbines when compared with steam turbines, which are only subjected to steam. There are two types of fuel applicable for gas turbines, liquid fuel and gas fuel.

(1) Liquid fuel

a) Viscosity and pour point

The viscosity and pour point of fuel are sensitive for fluidity and atomization at the fuel nozzle. If necessary, fuel should be heated to obtain necessary fluidity.

b) Residual carbon

It is necessary to select a proper fuel nozzle according to the potential residual carbon content to prevent it from generating smoke and adhering to the combustion chamber.

c) Muddy water

Muddy water contained in fuel oil causes clogging in the fuel processing and feeding system, which affects the life time and maintenance conditions of filters. The content of muddy water should be kept to as low a level as possible.

d) Ash content and metal content

Slag source contained in fuel oil causes erosion and slag adhesion in the gas turbine components exposed to high temperature. Attention should be paid to residual oil and crude oil, since they may contain these harmful substances.

Sodium, potassium, vanadium, etc. react with other substances in the combustion process and produce erosive compounds. Alkaline earth metals produce hard adhesive substances. Sodium and potassium can be removed with a centrifugal or electrostatic separator. However, there is no industrial method to remove vanadium. Therefore, magnesium in quantities three times as much as vanadium is normally added to fuel oil in the form of a magnesium compound.

e) Sulfur

Sulfur produces sulfide in the process of combustion, which accelerates erosion of gas turbines. Exhausting gas with sulfide content causes an adverse effect on the environment. However, it is difficult to reduce the sulfur content in liquid fuel. Sulfur erosion and adhesion could only be minimized by reducing the metal content in fuel.

(2) Gas Fuel

a) Impurities

The impurities contained in gas fuel are tar, carbon, coke, water, sand, clay, rust, and iron oxide, detergent, lubricant, naphthalene and gas hydrate, etc. These must be quite small in quantity. Gas fuel used for gas turbines should be dry.

b) Composition

Hydrogen sulfide (H_2S), sulfur dioxide (SO_2), sulfuric anhydride (SO) and carbon dioxide gas (CO) cause high temperature erosion of gas turbine blades and low temperature erosion of the fuel control system. Thus, the density of these substances should be as low as possible and proper preventive measures should be taken.

Sulfur and alkaline metals cause erosion similar to that mentioned under liquid fuel.

(Source: "Preventive Maintenance and Residual Life Diagnosis of Power Generation Plant" Thermal and Nuclear Power Engineering Society of Japan, 2002)

7.2.2 Ambient Temperature and Performance of Gas Turbines

The output and thermal efficiency of gas turbines are governed by the inlet gas temperature, which is influenced mainly by compressed air (oxygen) quantity and fuel quantity. Even if the gas turbine inlet temperature is maintained constant, the output and thermal efficiency of a gas turbine changes widely according to inlet air temperature and atmospheric pressure. Typical performance curves which vary with ambient temperature are shown in Figure 7.2-1.

It is noted that, according to the ISO standard, the rated output of a gas turbine is specified based on the conditions at the inlet flange of the air compressor, that is, an air temperature of 15℃, air pressure of 101.3 kPa and relative humidity of 60 %.

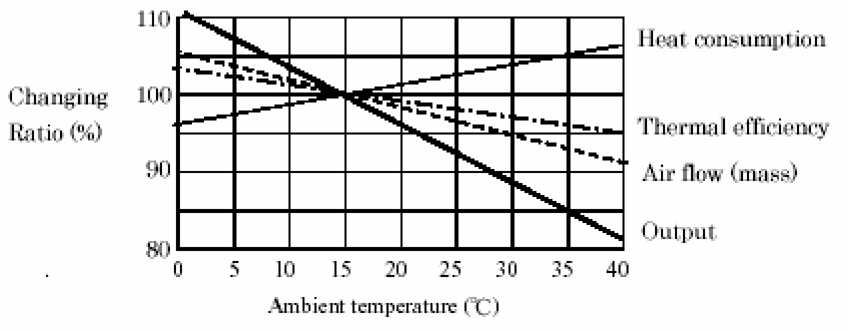


Figure 7.2-1 Performance due to Ambient Temperature

This figure shows that the output of a gas turbine decreases nearly 20% at an ambient temperature of 40℃ against the rated output at 15℃. On the other hand, it can be said that the output of a gas turbine can be increased if the inlet air temperature is decreased by any provision such as an inlet air cooler. On this point, the tentative calculation for application of a pre-cooler is shown in Appendix E.1.

7.2.3 Turbine Inlet Gas Temperature and Thermal Efficiency

Owing to the development of new heat resisting material and improvement of cooling and manufacturing technology, the operating gas temperature at the turbine inlet has increased remarkably. This also has resulted in the increase of thermal efficiency of gas turbine generation.

The relation between inlet gas temperature and thermal efficiency is shown below.

Inlet gas temperature (degree C)	Thermal efficiency (%, LHV base)	Remarks
1,150	34 ～ 35	(D)
1,350	35 ～ 36	(F)
1,500	38 ～ 40	(G) (H)

7.2.4 Operation and Maintenance of Gas Turbines

(1) Equivalent operating hours

The life time of parts which are exposed to combustion gas flows are influenced by two factors; one is creep damage due to creeping which is proportional to actual operating hours and the other is damage due to fatigue which is caused by start-stop and changing load etc. One of the methods to decide the maintenance interval is the "Equivalent Operating Hours" scheme. A typical formula to estimate the Equivalent Operating Hours scheme is described below.

Equivalent operating hours: $H_0 = H + S_0 \text{ x } A$ [h]

Equivalent starts (number): $S_0 = N + B \text{ x } L_R + C \text{ x } T + D \text{ x } L_C$ [number]

Where:

H: actual operating hours [h], A: coefficient for equivalent operating hours [h/number],
N: actual starts [number], B: number of load interruptions,
L_R: coefficient of load interruption, C: emergency stops [number],
T: coefficient of emergency stops, D: rapid load changes [number],
L_C: coefficient of rapid load change.

(Source: "Thermal Power Generation" IEEJ (Institute of Electrical Engineers of Japan)

The "equivalent operating hours" is obtained from the manufacturer, a sample of which is indicated in Appendix E.2 "Rated repair interval".

(2) De-rating Factor Method

The other method to decide the maintenance interval is the so called "De-rating Factor Method", which employs three factors to de-rate the rated repair interval; fuel factor, start frequency factor and loading factor. The details of this method are described in Appendix E.3.

7.3 Some Items to be Considered for Selection of New Generating Plant

It is recommended that new generating plant be introduced which is designed in accordance with internationally accepted standards. Furthermore, the following items should be considered in selecting new generating plant.

a) Any new plant, whether it is power generating plant, substation or distribution plant, should be located as near the power demand center as possible. This will save power transmission and distribution cost. However, this strategy may introduce a contradiction for the environmental protection aspects such as air pollution, water contamination, comfort of residents and influence on the ecological system, etc. Nowadays, environmental protection is a matter of top priority internationally. Even minimum cost plant design should take this environmental principle into consideration. Environmental issues are described in Chapter 8.

b) Power generating plant located near the demand center sometimes faces disadvantages in obtaining fuel and cooling water. In Iraq the largest demand center is in the Baghdad area, but that area is not blessed with natural gas. The main gas fields are located in the Northern and Southern areas. In this situation, any power generating plant in Baghdad has a cost burden of fuel transportation. If the plant is located near a fuel-rich place, it will save fuel transportation costs but attracts power transmission costs. The location of new power generating plant needs to be selected considering this trade-off relationship between fuel transportation cost and electric power transmission cost.

c) The fuel characteristics, such as viscosity and content, are the most important factors, as they affect the maintenance conditions and life-time of plant. As already described in Chapter 3, the crude oil and fuel oil in Iraq contain a considerable amount of content harmful to the life of the equipment. An inspection and repair plan should be carefully prepared by utilizing data obtained from the existing plant and employing state-of-the-art maintenance technology. The inspection and repair interval is affected by operation and maintenance conditions. The methods used to decide the inspection and repair interval of gas turbines is mentioned in Chapter 7.2.4. Similar technology may be applied for equipment and material exposed to high temperatures.

Proper operation and maintenance management should be introduced for boilers, steam turbines, generators and plant auxiliary equipment. The total scheme for operation and maintenance management is shown in Appendix H.1 for reference.

The deterioration diagnosis and residual life assessment technology for power generating plant are also summarized in Appendix H.2 as a result of improvement of technology for evaluating the condition and life of equipment in Japan. .

d) Steam turbine plant requires a large amount of condenser cooling water. The location of the water intake and exhaust point is very important.

A water intake is likely to be clogged with plants and marine materials. Installation of proper screens and injection of chlorine gas into the intake line may be considered. However, negative effects such as corrosion of piping, condenser and other parts should also be considered.

The return of high temperature water to the river or sea will have a significant influence on the ecological system. Prior to commencement of plant design, a comprehensive environmental assessment, including warm water flow simulation, is required.

If the required amount of water cannot be obtained from a river or other source, a closed water circulation system utilizing a cooling tower may be introduced. However, even in this case, about 5 % of the circulation water is required for make-up water.

e) Quality of water is also very important. Boiler feed water should be controlled properly in accordance with the boiler manufacturer’s recommendation. The circulating cooling water characteristics are also important to prevent corrosion and accumulation of deposits. A proper water treatment plant should be considered taking into account the characteristics of the raw water.

Waste water from the plant, such as boiler blow down, spilled water and oil containing water, should be controlled in a comprehensive manner for protection of rivers, sea and soil.

f) The specifications of plant equipment, which aim to withstand severe climate conditions such as high ambient temperature, high humidity and dusty sand-storming conditions should be established as general conditions to be observed by any plant equipment supplier. Severe atmospheric conditions are applied to the auxiliary equipment such as water pumps, fuel pumps, blowers, air conditioning units and instrumentation, which are mostly installed outdoors. Fully organized management in design, procurement and installation is required.

7.4 Introduction of Combined-Cycle Generation

7.4.1 Outline of Combined-Cycle Power Generation

The gas turbine combined-cycle power generation system, that is simply called "combined-cycle generation", is a combination of gas turbine generation and steam turbine generation which is composed of boiler and steam turbine. This system is gaining ground with thermal generation in the countries where gas fuel is available and efficient use of the energy source is required.

The outline of combined-cycle generation is illustrated in Figure 7.4-1.

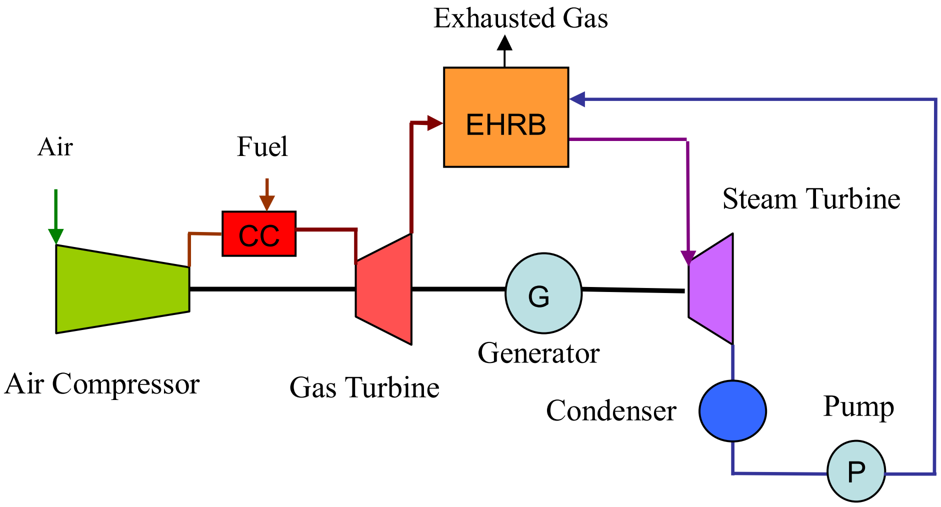


Figure 7.4-1 Principle of Combined-Cycle Generation

7.4.2 Specific Features of Combined-Cycle Generation

a) High thermal efficiency

The main advantage of adopting combined-cycle generation is high thermal efficiency as a combined plant, which is realized by utilizing exhausted gas energy as input to a boiler. The other reason that makes this type of power generation feasible is the improvement of heat-resisting material used in gas turbines. In the case where the inlet gas temperature of the gas turbine is 1,500℃, the thermal efficiency of the total plant comes near 60 % calculated by the LHV (Lower Heating Value) of fuel.

b) High performance to meet changing load

The combined-cycle generation system is composed of small units of generator, compared with one big unit in steam turbine generation. To meet changing load and partial load, a number of small generating units, which have short start-stop time characteristics, can be chosen. Owing to these characteristics the overall thermal efficiency of the plant is much improved as compared with steam turbine plant. An image of plant thermal efficiency for combined-cycle generation and steam turbine generation is illustrated in Figure 7.4-2.

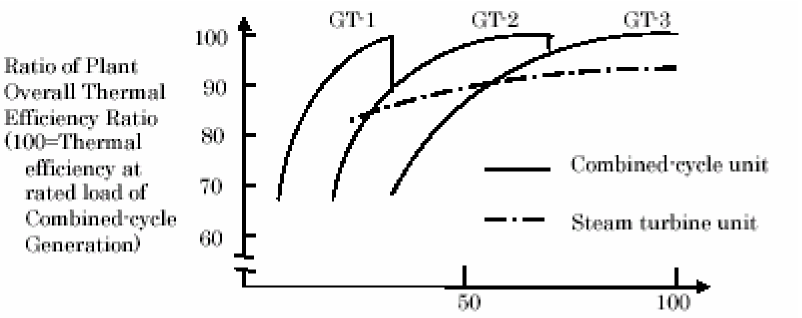


Figure 7.4-2 Overall Characteristics of Thermal Plant Efficiency

c) Environmental aspects

Higher thermal efficiency leads to less emission of exhausted CO_2 gas into the air. Compared with steam turbine generation of the same output, combined-cycle generation has a steam turbine of around 1/3 capacity only. This means less cooling water produced from the condenser. Nitrogen oxide contained in the exhausted gas can be reduced by employing a low NOx type burner and installation of a flue gas denitrification unit.

d) Other characteristics

The specific features of gas turbines such as output dependability on ambient temperature (inlet air) and influence of fuel are commonly applied for combined-cycle generation.

7.4.3 Structure of Combined-Cycle Generation

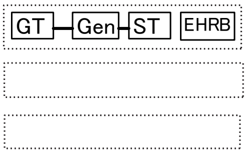
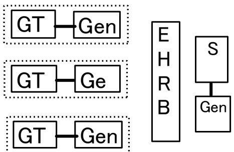
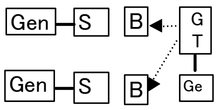
There are two types of combined-cycle generation, single-shaft type and multi-shaft type, which are classified by the combination of gas turbine and steam turbine. The typical arrangement of components of combined-cycle generation is shown in Table 7.4-1.

The single-shaft type has a gas turbine, a steam turbine and a generator, all aligned on the same shaft. The combined-cycle generation plant usually has multiple lots of single-shaft type units and they are operated as independent units.

The multi-shaft type has multiple units of gas turbine generator and boiler and one steam turbine generator. For this type, the capacity of the steam turbine generator can be larger compared with the single-shaft type, which is more advantageous for thermal efficiency.

Further, the typical structure of capacity oriented combined-cycle generation is shown in Table 7.4-1 for one-shaft type, multi-shaft type and repowering as explained in Chapter 7.4.5

Table 7.4-1 Typical Components of Combined Cycle Generation

Model	Type		Site Capacity	No.of GT	Unit Type(Typical)	Operation & Maintenace	Efficiency
S-1	Single Shaft Type		350MW	1	M701F+ST MS9001FA+S	1.Line-wise operation for partial load. 2.Shorter starting time. 3.Line-wise maintenance	1.Higher efficiency for partial load.
S-2				2	MS9001E+ST		
S-3				3	MS6001FA+ST MS6001B+ST		
M-1-2	Multi-shaft Type		350MW	2	MS9001E+ST MS701DA	1.Any unit of GT/ST is stopped for partial load. 2.Maintenance of EHRB requires some arrangement..	1.High efficiency for full load. 2.Lower efficiency for partial load
M-1-3				3	MS6001FA+S		
M-2			500MW	3	MS9001E		
M-3			600MW	3	M701DA		
M-4			700MW		(Two of M-1)		
R-1	Repowering		400MW			(Dura)	
R-2			550MW			(Beji, Nasriya,Hartha)	
R-3			700MW			(Mussaib)	

7.4.4 Staged Implementation of Combined-Cycle Generation

The other advantage of combined-cycle generation is the possibility of staged installation of equipment. For an example, a simple cycle gas turbine generator that has a short delivery period is installed first and starts operation to meet emerging needs. It is possible that an EHRB and a steam turbine generator may come later for installation. This arrangement is easy in the case of the multi-shaft type and is not impossible even for the single shaft type if space for an EHRB is provided. This means the existing gas turbine power plant has the possibility of being modified to combined-cycle generation by adding an EHRB and steam turbine generator.

7.4.5 Repowering System

This system was developed for the purpose of enhancement of existing steam turbine plant by adding gas turbine generators. The exhaust gas from the gas turbine is input to an existing boiler. This will increase the total thermal efficiency of the plant by saving fuel for steam turbine generation. This system has advantages for simple modification work and short delivery period. In Japan there is an experience for repowering. The modification period for the repowering was 6 months, and it gained 36 % increase of plant capacity and 7% increase of plant thermal efficiency.

7.5 Introduction of Renewable Energy

In terms of sustainable energy development and environmental aspects, the renewable energy resources, such as solar energy, wind energy, small to middle scale hydropower and biomass energy, have been introduced and implemented in many developing and developed countries in recent years.

It is observed that the economic aspects of the renewable energies are still not competitive against the conventional energies such as thermal power, gas turbine and large scale hydropower. However, they have been gaining a higher competitiveness in recent years as the technologies are developed and also as the business markets grow. Consequently, renewable energy is conceived to be one of the most important options for middle to long term power development.

Renewable energy is especially suitable for off-grid or say mini-grid areas, where the electricity network is disconnected from the national grid. Its development depends on site conditions for each project.

Glancing at the climate in Iraq, it seems that the country has huge potential for renewable energy. According to the 10 Year Plan of the Commission of Electricity by CoE (2002), some solar and wind energy projects are planned for implementation. However, the current status of the projects is not known.

(1) Solar Energy

Considering the climate in Iraq, the most promising renewable energy is solar energy. The following table shows data of the solar irradiance in Iraq.

Table 7.5-1 Direct Normal Irradiance (RETScreen-type Method)

Unit: kWh/m^2/day

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
North (Mosul)	2.77	2.83	3.52	4.55	5.93	8.00	8.43	8.11	7.04	4.97	3.40	2.63	5.18
Middle (Baghdad)	3.89	4.42	4.57	5.14	6.62	8.60	8.61	8.29	7.21	5.60	4.07	3.73	5.90
West (Rutba)	4.04	4.56	4.85	5.49	6.86	8.66	8.79	8.36	7.08	5.70	4.41	3.95	6.06
South (Basrah)	4.18	4.98	4.79	5.38	6.86	8.69	8.78	8.47	7.50	6.27	4.58	4.06	6.21

Data source: NASA Surface meteorology and Solar Energy

Note: North = Latitude 36° , Longitude 43° , Middle = Lat 33° , Lon 44° , West = Lat 33° , Lon 40° , South = Lat 30° , Lon 47° .

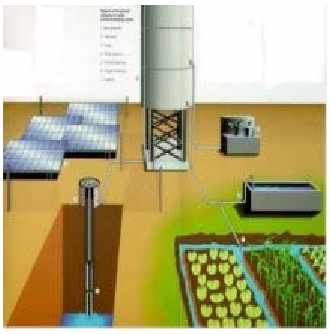
The data is a 10 year average.

As seen in the above table, 5 to 6 kWh/m^2 of solar irradiance is very promising as it is ranked at the highest level in the world.

According to the Needs Assessment of the Electricity Sector of Iraq by WB (2003), it is reported that the solar energy is to be exploited in the following domains:

- Domestic Solar Heater;
- Solar space heating and air conditioning;
- Solar thermal electricity generation; and
- Photovoltaic conversion of sun energy directly to electricity.

Though detailed examination might be necessary to conclude availability or sustainability of solar energy, it seems that there is no serious obstacle to exploiting the high potential for solar energy in Iraq.



PV Water Pumping System

http://www.worldbank.org/html/fpd/energy/subenergy/solar/water_pumping.htm

(2) Wind Energy

There is insufficient data for wind energy available in Iraq. However, it is expected that certain areas of the country would have some wind energy potential.

The wind speed data at 50 m above the ground in Iraq are shown below.

Table 7.5-2 Wind Speed at 50 m Above Ground

Unit: m/s

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
North (Mosul)	4.69	5.25	6.09	6.42	6.00	6.73	8.00	7.77	6.01	5.01	4.18	4.43	5.88
Middle (Baghdad)	4.65	5.05	5.32	5.39	5.73	6.19	6.04	5.89	5.51	5.23	4.76	4.70	5.37
West (Rutba)	4.40	4.84	4.82	4.82	5.05	5.76	5.96	5.74	4.87	4.55	4.34	4.36	4.96
South (Basrah)	4.42	4.63	4.74	4.69	5.57	6.10	5.58	5.43	5.09	4.63	4.62	4.55	5.00

Data source: NASA Surface meteorology and Solar Energy

Note: North = Latitude 36° , Longitude 43° , Middle = Lat 33° , Lon 44° , West = Lat 33° , Lon 40° , South = Lat 30° , Lon 47° .

The data is a 10 year average.

It is commonly said that average wind speeds above 5 m/s is promising for installing wind farms to generate electricity from an economic viewpoint. The above data appear to indicate a great potential for wind energy in all the regions.

(3) Hydrogen Energy (Fuel Cell)

In addition to the above renewable energies, hydrogen energy (Fuel Cells) also will become one of the most important energy sources for the electricity sector in the middle to long term power development.

Hydrogen energy can be utilized in many kinds of sectors such as the industry sector, electricity sector, public welfare sector, transportation sector, and so on. Regarding use of hydrogen energy in the electricity sector, the Fuel Cell is the most promising technology for the near future. The concept of the Fuel Cell is the contrary action of electrolysis. That is, the Fuel Cell produces electricity (and water) from hydrogen and oxygen.

The following figure shows an image of electrification by renewable energy in rural areas.

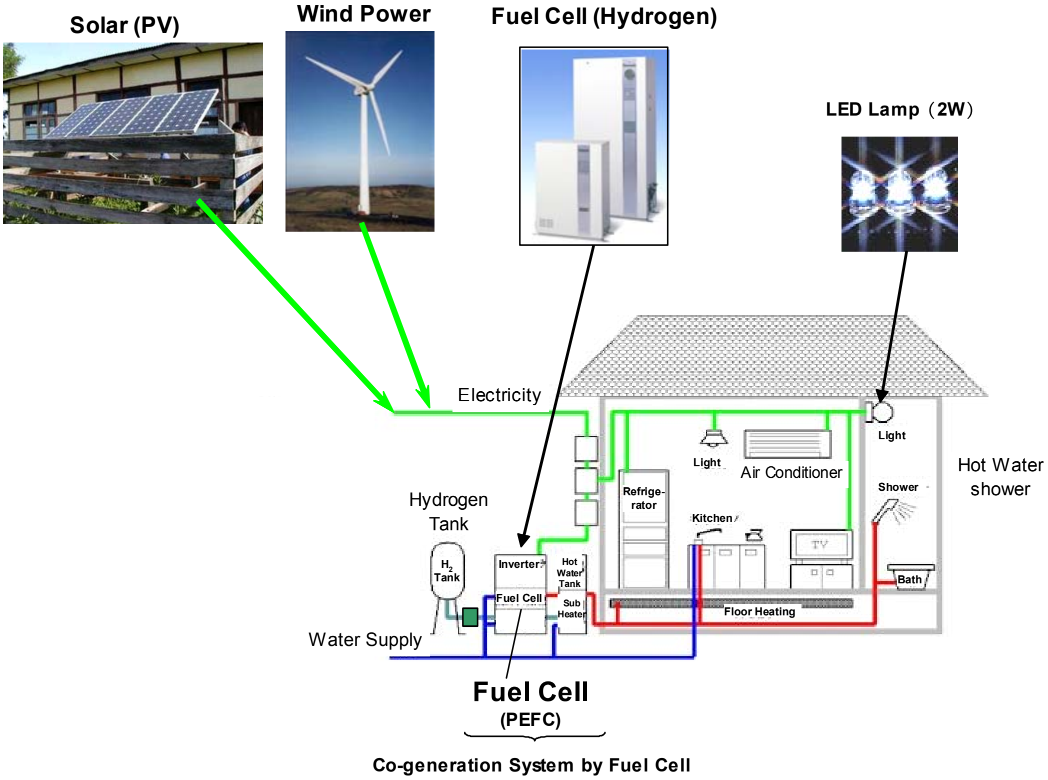


Figure 7.5-1 Image of Electrification by Renewable Energy in Rural Areas

It is expected that costs of those renewable energies would decrease considerably in the near future, while the conventional type energies are reaching a marginal level in cost reduction. Considering a balance between cost and benefit, a well-balanced and sustainable development should be searched for using the appropriate energies in the future of Iraq.

CHAPTER 8 ENVIRONMENTAL ASPECTS

8.1 Current Situation

The Needs Assessment Report outlines the environmental issues in the present generation system in Iraq. According to the report, there is a lack of normal environmental protection schemes, which has caused a serious threat to the environment. In general uncontrolled power station emissions and thermal pollution of waterways severely affect the local ecosystems.

According to the field study conducted by Dr. Rasool of the Chemical Engineering Department of the University of Baghdad, which is presented in the report on the Needs Assessment for the electricity sector, the content of fuel presently used in the existing power generating plants was analyzed as shown in Table 8.1-1.

Table 8.1-1 Chemical Analysis of Fuel used by Baghdad South PS

Element	% Weight basis	% Molar basis
C	86	39.2
H	11	60.2
S	3	0.5
N	0.1	0.04
O	0.1	0.03

Source: Field study conducted by Dr. Rasool of the Chemical Engineering Department of the University of Baghdad referred to in the Needs Assessment report.

From the table, it is known that the carbon weight % is very high compared to hydrogen, which indicates that the station uses heavy fuel oil with high Sulphur content.

Dr. Rasool conducted an analysis of the exhausted gases from the chimney as shown in Table 8.1-2.

Table 8.1-2 Exhaust Gases of Baghdad South PS

Gases	% Molar basis						
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Average
CO_2	10	10	10	9.5	-	11.5	10
CO	9	5	8	8.5	-	8	7.7
SO_2	0.5	0.7	1	0.4	-	0.6	0.64
O_2	1	1.5	2	1.5	-	1	1.4
N_2 + other Gases	80.5	82.5	79	80.1	-	78.9	80.2

Note: Unit 5 was not operating at the time of analysis.

Source: Field study conducted by Dr. Rasool of the Chemical Engineering Department of the University of Baghdad referred to in the Needs Assessment report.

More data on air pollution for the oil-fired power stations are presented in Table 8.1-3, which were reportedly estimated by the consultant under WB for the Needs Assessment using the data obtained from the CoE engineers.

Table 8.1-3 Air Pollution Sources for Iraq's Main Power Stations

Power Station	Rated power MW	Flue Gas Quantities (1000 m^3/hr)			
		Total	CO_2	CO	SO_2
Baiji	530	3,900	390	300	23
Doura	300	1,870	187	144	11
Baghdad South	200	1,339	134	103	8
Musaib	650	2,676	268	206	16
Nassiryah	500	2,600	260	200	16
Hartha	320	2,520	252	194	15
Najibia	200	2,202	220	170	13

Source: Field study conducted by Dr. Rasool of the Chemical Engineering Department of the University of Baghdad referred to in the Needs Assessment report.

It is clear from the table that great efforts and/or substantial funds will be needed for environmental protection systems in the near future and the supply of non-polluting fuel for power generation is seriously required.

Steam thermal power plants require appreciable amounts of demineralized water, which is produced by a series of treatment processes including reverse osmosis, ion exchange, etc. These processes discharge waste water to the nearby rivers as shown in Table 8.1-4.

Table 8.1-4 Industrial Waste Water Effluents discharged by Iraq's Main PSs

Power Station	Industrial Waste Water m^3/hr
Baiji	350
Doura	300
Baghdad South	200
Mussaib	500
Nassiryah	400
Hartha	350
Najibia	250

Further studies are needed to identify and quantify the specific water pollution elements released by each power plant.

Most of the steam thermal power stations are situated on the river banks, where water is taken to cool the turbine condenser called "open" or "once through cycle". The quantity of water withdrawn from these rivers is around 40 l/s per MW. For a power station of 1,000 MW it is necessary to withdraw 40 m^3/s, which is around 10% of the total water of those rivers flowing in the summer season.

This water is returned to the river with a temperature rise of around 10^oC. This temperature rise has a detrimental effect on the marine life and ecosystem of these rivers, e.g., fish and plants. The following table shows the average quantity of water withdrawn from the rivers for cooling water purposes.

Table 8.1-5 Cooling Water Use for Iraq's Main PSs

Power Station	Water Flow Rate m3/hr	River
Baiji	185,760	Tigris
Doura	117,280	Tigris
Baghdad South	117,280	Tigris
Mussaib	212,320	Euphrates
Nassiryah	160,000	Euphrates
Hartha	101,400	Shat Al Arab
Najibia	50,760	Garma

Most of the above mentioned power stations suffer greatly in summer from the reduced levels and discharge rates in the rivers, especially in Nassiryah, Doura, and Baghdad South. To overcome this problem, the use of closed cooling systems or cooling towers in the new power stations is highly recommended. Combined cycle plant has a higher overall thermal efficiency and would contribute to reduction of the required amount of water.

In the case that small diesel generators are used in the immediate to short term, an environment management program should be introduced to ensure the safe storage and handling of diesel fuel and lubrication oil. This should also include procedures for the proper storage and disposal of waste lubricating oil and sludge from storage tanks, the containment of transformer oil and fuel oil spills as well as the control and disposal of any remaining polychlorinated biphenyls (PCBs).

The following issues are pointed out as other miscellaneous pollutions.

- Pollution due to oil spills from broken or sabotaged pipelines.
- Pollution due to spent lubricating and transformers oil, as no recycling plants are currently available.
- Noise pollution due to the operation of machinery and equipment related to the electricity sector.
- Visual pollution due to high rise chimneys and transmission line towers.

8.2 Regulations on the Environment

There are relevant laws on the environment applicable for the electricity sector.

Table 8.2-1 Relevant Iraqi Environmental Legislation

Title	Type	No.	Year
Conservation of Hydrocarbon Wealth	Law	84	1985
Environment Protection	Law	76	1986
River Maintenance	Instructions	25	1967
Environmental Improvement and Protection	Law	3	1997

According to the Needs Assessment report, no evidence was seen that the current planning process for new plant or rehabilitation of old plant takes into consideration any specific guidelines for acceptable pollution levels for air or water. It is explained that lack of compliance with such environmental regulations is caused by lack of funds or unavailability of certain chemicals under the sanction regime.

An environmental audit of all thermal and diesel based power plants should be implemented as soon as possible, including the existing status of pollution control systems, fuel and oil storage tanks.

It is noted that environmental monitoring is not carried out and there is no evidence that any existing environmental legislation is enforced. A shift towards gas based combined cycle generation and away from conventional thermal types would be an important factor for mitigating the environmental impact of the electricity sector. Also the potential use of renewable energy including hydropower should not be underestimated.

Energy conservation programs should be addressed and be more encouraged. The use of energy efficient appliances by all consumers is recommended in line with the implementation of demand side management programs. Solar water heating is another effective power usage reduction program that can be implemented.

All new power projects should be subject to an Environmental Impact Assessment (EIA) study as part of project design and preparation works. Introduction of appropriate pricing policies would contribute much to provide incentives for improving the efficiency of operations and conservation of energy. In the power system expansion program, environmental costs should be properly and fully allocated in order to implement environmental and social impact mitigation plans.

8.3 Clean Development Mechanism (CDM)

Iraq has not signed the Kyoto Protocol on the emission reduction target. However, under the increasing global concern on the environment, it is necessary for Iraq to make more effort for environmental protection. Hereinafter, Clean Development Mechanism (CDM) is briefly mentioned.

Clean Development Mechanism (CDM) was established under the Kyoto Protocol (COP3, 1997) to the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The purpose of the CDM is to meet the emission reduction target of the Annex I countries (developed countries and those economies in transition) and to achieve sustainable development of the non-Annex I countries (developing countries). In 2001, the Marrakech Accord was adopted at the Conference (COP7), which defines the rule for administering the Kyoto Mechanism. The CDM procedures are basically administered on the Marrakech Accord.

The CDM encourages the Annex 1 countries to carry out projects which reduce carbon emission in the Non-Annex 1 countries and to earn Certified Emission Reduction credits (CERs). CERs generated from CDM projects can be used by the Annex 1 countries to offset their national emission reduction commitments under the Kyoto Protocol.

The CDM will enable the Annex 1 countries to minimize the cost of complying with their greenhouse gas (GHG) emission reduction targets, while affording private companies and investors the opportunity to earn money from the sale of CERs in markets.

It is not clear at the moment how the actual CDM system works. It may take some time before clear rules are established. However, it is clear that every country has obligations to respond to climate change. European countries, who have signed the Kyoto Protocol, have already started trading carbon emissions.

It is stressed that development of CDM projects should be considered as “Prior Investment” for the Annex 1 countries, including Japan, and study to identify specific projects in the Non Annex 1 countries should be encouraged to be ready for the accreditation of Certified Emissions Reductions (CERs).

CHAPTER 9 SHORT-TERM DEVELOPMENT PROJECTS

9.1 Emergency Requirements in the Short-Term

It is apparent that the emergency needs for the power sector is to continue rehabilitation and repair works of the existing plants and networks. Further the committed projects mentioned in Section 5.1.2 are expected to complete as soon as possible. Even if those rehabilitation and committed projects are completed, the dependable supply capacity of the generating plants would be as follows:

Existing plant	: 5,926MW
Committed plants	: 1,760MW
Total	: 7,686MW

However, the above capacity would be marginal to meet the peak demand in the high demand summer time in 2005 which is forecasted at 7,039MW. It is necessary to add new installation immediately, for which some preparatory and relevant works including provision of fuel supply should be started.

The rehabilitation and replacement project for the existing plants which are now under discussion for implementation by foreign assistance are also expected to complete as early as possible. Even if these are completed, additional capacity would be 300MW or so in total.

9.2 Condition Assessment and Life Evaluation of Generating Plants

Power generating equipment needs to be operated and maintained under the proper management to secure soundness and reliability of equipment and for stable power supply. This management normally includes the operation management and maintenance management, the scheme of which is mentioned in Appendix F.1 (Operation and Maintenance Management Cycle of Thermal Plant).

Prior to the start of proper operation and maintenance management, it is necessary to know exactly the present condition of equipment. This technology is known as equipment condition diagnosis and assessment, which are widely adopted in advanced countries. This technology is achievable with a combination of the hardware, such as measuring and testing instruments, and the software of accumulated knowledge and data. The residual life of equipment can be evaluated by supplying this technology.

The applicable diagnosis and test technologies and the residual life assessment technologies for the respective component/place of power plant equipment are summarized in Appendix F.2 (Power Plant Deterioration Diagnosis and Residual Life Assessment).

It is recommended firstly to make an inspection and repair plan for equipment which has operated more than twenty years using condition diagnosis technology. The experts in this field should be invited for attendance for precise inspection. The operation and maintenance records of the equipment are also important for assessing the residual life.

9.3 Introduction of New Schemes for the Existing Thermal Plants

It has become a common understanding that utilization of exhaust gas from gas turbines for the boilers of steam turbines has various advantages, such as increase of power generating capacity and thermal efficiency, and also reduction of environmental burden. There are two schemes to achieve the utilization of exhaust gas from gas turbines, the details of which are described in Section 7.4.

- Installation of exhaust gas heat recovery boilers (EHRBs) and steam turbines at gas turbine plant: so called “Combined Cycle” power generation
- Installation of gas turbine generators and utilization of exhaust gas for Heat Recovery Steam Generators (HRSGs), so called “Re-powering”

In various ongoing and committed generation projects, it is recommended that MoE seek the possibility of application of any of the above schemes. In particular, the “Re-powering” scheme can be realized in a shorter period compared with the “Combined Cycle” scheme.

9.4 Capacity Building

Capacity building in the electricity sector is earnestly required. This Study has an objective to contribute to the human resources development in the electricity sector.

During the study period, the study team had several opportunities to exchange views on rehabilitation works and new technology with the MoE’s engineers and staffs.

World Bank has a plan for rehabilitation and development of the training centers of MoE, including training staff of the centers. JICA is executing a program for capacity building in the field of power system operation and analysis, and SCADA and communication systems. This training is carried out at Amman in cooperation with NEPCO (National Electric Power Company), Jordan.

JICA handed over the following instruments to MoE in June 2004.

- High voltage measuring device (HCL-1000D),15 units
- Hot stick TEL-POLE, 15 sets
- Power analyzer and recorder, Model MPR-600S,15 sets

These instruments will be used to measure voltage and power factors in the distribution lines with accuracy and regularly or when necessary. Training for use of the instruments and data processing will be done by the UNDP's experts who already had similar experiences in the northern governorates.

CHAPTER 10 MIDDLE TO LONG TERM DEVELOPMENT PLAN (2008 TO 2020)

10.1 Basic Considerations for Middle to Long Term Development Plan

It is essential to develop a power system in the long term for increasing power demand. Usually power development needs a huge amount of investment and a long lead time until the power is commissioned to be available in the system. As also stressed in Chapter 6, the power facilities should be provided in a well-balanced manner among generation, transmission, substations, distribution and dispatching and control. In other words, the electricity generated should be delivered to the end users with sufficiency and stability and without delay.

Prior to any implementation of thermal projects, supporting infrastructures such as fuel supply systems should be established in close discussion and coordination with other agencies. Most of the facilities are large in size, which may cause some adverse effects on the environment, and therefore prior to the implementation, environmental assessment is essential, especially in the case where projects are implemented with international assistance and cooperation.

Under the serious shortage of power supply capacity at present, urgent measures such as rehabilitation and repair of existing facilities should be given top priority and be continuously undertaken. Further, installation of new plant and facilities should be planned properly and be realized stepwise in line with an electricity master plan under the above mentioned policies.

In this chapter, a simulation was made on a preliminary basis to seek for the probable candidate for new generation plants to be introduced to the power system for the demand forecast which places a time horizon in 2020. Expansion of the generating equipment in the system was examined using the EGEAS software (Electric Generation Expansion Analysis System). However, it is noted that this simulation should be reviewed in due time based on more reliable data and in light of the updated MoE's and the national policy on energy production and consumption. The basic conditions and procedures for the simulation are described hereinafter.

10.2 Generation Expansion Plan

10.2.1 General

For the simulation of generation expansion plan, generation plants were categorized into three groups. The first is the existing plants for which repair and rehabilitation are underway. The second is generation plants which are committed by MoE to be developed by 2005, for which construction work are partly implemented. The third is new generating plants which are considered to be possible new candidates to be added.

If the maintenance and repair of the existing power stations are properly made, the total of available operating capacity of the main existing power stations in Iraq in the year 2004 would be 5,926 MW. Appendix C.1 shows the total available operating capacities of the main existing power stations, and Appendix C.2 shows the total available commissioned capacity in the year 2005.

Due to a delay in the rehabilitation process and as new capacities would be commissioned from the year 2006, an assumption was made that there would be no retirement of units till the end of the year 2007.

Required energy in the year 2005 is foreseen at about 46,000 GWh and will increase with an annual rate of 6 to 8 % as discussed in Chapter 6.

10.2.2 Three Optional Scenarios Examined in the Study

For the analysis of the generation expansion plan, the following three optional cases were examined, of which details are given in Appendix C.3.

(1) Option Case 1: Conventional Thermal Plants

In option case 1, three steam power stations and six gas turbine power stations are considered as candidates for the generation expansion plan up to 2020.

(2) Option Case 2: Renovation of Existing Thermal Plants and Hydropower Plants

In option case 2, three thermal power stations, five gas turbine power stations and two hydropower stations were considered as candidates for the generation expansion plan. The 400 MW capacity of Hartha new gas turbine power station of option case 1 was replaced by a hydropower capacity of 660 MW by Bakhma power station and Al Mokuhhol power station.

(3) Option Case 3: Renovation of Existing Thermal Plants, High Efficient Thermal Plants, Hydropower Plants and Renewable Energy Plants

Option case 3 includes high efficient combined cycle power stations instead of the five gas turbine power station in option case 2. It was assumed that introducing high efficient combined cycle plants would raise the thermal efficiency by at least 30%.

It is also believed that Iraq has a remarkable solar energy potential all over the country and an appreciable potential of wind power in the south and south west of the country. Though recommended, renewable energies are not included in the analysis.

10.2.3 Cost Estimate

For the generation expansion plan it is necessary to estimate the capital installation cost, fixed and variable operation and maintenance costs for each plant, consumed fuel costs and unserved energy cost. Cost estimate should be made based on the past and present local levels and forecasted inflation. However, as for the recent situation in Iraq, it is too difficult to estimate the exact local cost levels. Therefore, analysis of cost related data in the neigbouring countries and on an international level could help in estimating the necessary costs. Details of different costs are given in the economic analysis.

10.2.4 Basic Conditions and Economic Analysis

The main objective of the generation expansion plan analysis is to estimate the size and timing of each planned power plant, to obtain economically the least cost combination, to determine the year of installation of each power plant and to examine their physical and economic benefit in the extended system.

The study assumes that all alternative expansion plants offer the same total benefit and therefore the minimum cost plan yields maximum benefits to consumers. In other words, the analysis aims to determine the minimum cost expansion plan.

It is of great importance to note that all costs considered in the analysis are those directly connected to electricity generation. Thus, taxes, duties, social, external costs, etc. are disregarded. All costs are given in US dollars.

The optimization analysis is carried out by means of the Electric Generation Expansion Analysis System (EGEAS) software program. Basic necessary input data for EGEAS are as follows:

Table 10.2-1 Basic Necessary Input Data for EGEAS

(1) Unit Load Heat Rate					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Unit of Mass	TON	TON	MCF	MCF	------
Heat Content (Mbtu/Mass Unit)	40.87	42.86	0.98	0.69	------
Heat Rate (Btu/kWh)	10,300	10,800	13,127	9,200	------
(2) Fuel Types and Costs					
Fuel Name	Fuel Oil	Diesel	Crude Oil	Gas	Hydropower
Unit of Mass	TON	TON	TON	MCF	------
Direct Fuel Cost (US$/Mass Unit)	140.89	175.61	108.70	2.70	------
Direct Fuel Cost (US$/Mbtu)	3.447	4.097	2.536	2.750	------
Fuel Cost Annual Escalating Rate%	1.0	1.0	1.0	0.7	------
(3) Base Year for the Analysis	2004（Base year of the present value）				
(4) Discount Rate to the Installation Cost	10%				
(5) Number of Hours per Day	8,766（Average including leap years）				
(6) Installation Year	The calendar year in which the unit becomes or became operational				
(7) Plant Operating Life					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Operating Life (Year)	30	20	20	25	50
(8) Plant Book Life (only for Candidates)	Number of years over which the capital fixed charges are applied				
(9) Unit Rated Capacity	Given in MW				
(10) Equivalent Forced Outage Rate					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Outage Rate (%)	0.124	0.140	0.082	0.010	0.008
(11) Annual Energy Limitation	Given in GWh and applied only for Hydropower Plants				
(12) Design Capacity Factor	Specified for all units				
(13) Capital Installation Cost					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Capital Installation Cost (US$/kW)	1,100	600	700	1,100	1,500
(14) Levelized Carrying Charge					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Levelized Carrying Charge %	10.6	11.8	11.8	11.0	10.1
(15) Operating and Maintenance Costs					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Fixed O & M Cost (US$/kW/Y)	2.5	3.0	2.0	2.0	1.0
Variable O & M Cost (US$/MWh)	0.8	2.8	2.5	2.0	------
O & M Costs Annual Escalating Rate %	1.0	1.0	1.0	1.0	1.0
(16) Unserved Energy Cost	200 US$/MWh with 0.5 % annual escalation rate				
(17) First Year Available for Installation	2005				
(18) Last Year Available for Installation	2020				
(19) System Reliability Constraints					
First Year Applied	2005				
Minimum Reserve Margin %	0.0				
Maximum Reserve Margin %	20.0				
Maximum Expected Loss of Load (Hours/Year)	100.0				
Maximum Expected Unmet Energy %	3.0				
(20) Annual Expected Maintenance Weeks					
Unit Type	Steam	Diesel	Gas (S/C)	Gas (C/C)	Hydropower
Annual Expected Maintenance Weeks per Year	6	7	4	4	1
(21) Forseen Annual Energy and Daily Load	Based on the information provided by the National Dispatch Cenetr (NDC) of the MoE and shown in Figures 10.2-1 and 10.2-2				

In addition to the above, demand data for the analysis are shown in the following figures.

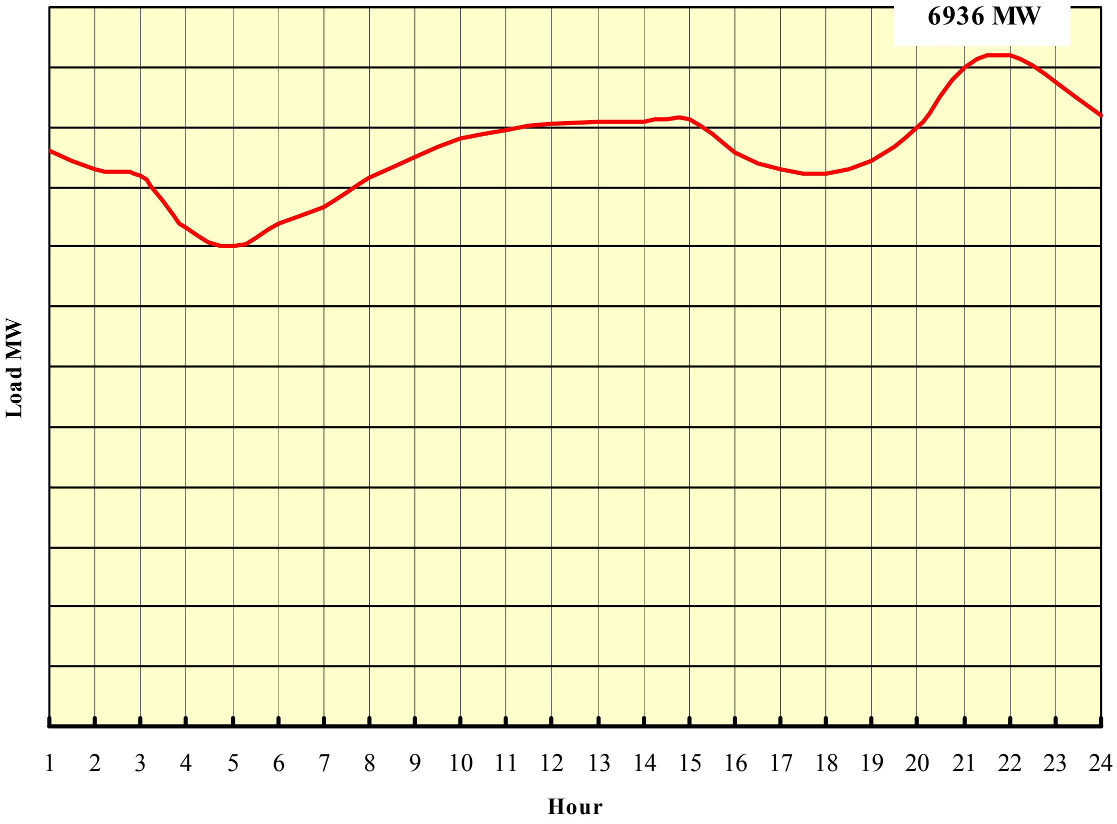


Figure 10.2-1 Estimated Daily Load in Iraq in Summer 2004

The foreseen annual energy and peak demand at the power station generating points for the period 2004-2020 is shown in the following figure:

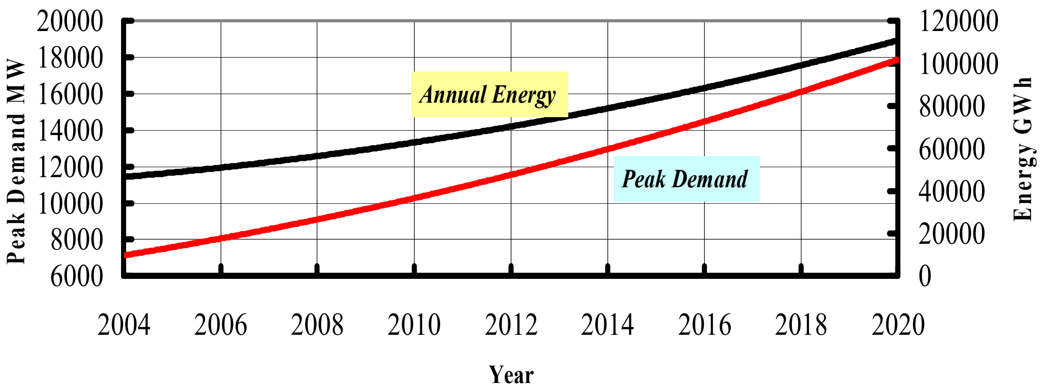


Figure 10.2-2 Annual Energy and Peak Demand

Appendix D.4 shows the schedule of commissioning the recommended candidates of the three option cases which are mentioned in Section 10.2.2. A net capacity of 18,680 MW is required at the end of the expansion plan with a reserve margin of 3.23 %. The reserve margin lies between about 3 % and 14 % for all cases with an average value around 8 %.

10.2.5 Recommended Generation Expansion Plan

Appendix C.4 shows the results of examination for each of the three option cases.

Appendices C.5 to C.9 show the fuel quantity consumed and costs for the three option cases throughout the period of the expansion plan. Comparison of the fuel costs for the three cases is also graphed as shown in Appendix C.10. Appendices C.11 to C.14 show the comparison of the annual consumption of each type of fuel for the three cases. The total annual fuel cost for each of the three option cases is tabulated here below. The table shows that commissioning of high efficient combined cycle units to the power generation grid would reduce the total fuel cost by over 20 %, comparing with commissioning of conventional thermal units.

Table 10.2-2 Total Annual Fuel Cost in Million US Dollars

Year	**Case**		
	Option Case 1	Option Case 2	Option Case 3
2006	1,473	1,473	1,473
2007	1,538	1,538	1,538
2008	1,751	1,760	1,645
2009	1,950	1,954	1,731
2010	2,110	2,114	1,839
2011	2,176	2,240	1,902
2012	2,352	2,256	1,936
2013	2,538	2,468	2,048
2014	2,771	2,684	2,097
2015	2,965	2,883	2,257
2016	3,142	3,014	2,359
2017	3,379	3,341	2,543
2018	3,585	3,469	2,672
2019	3,849	3,724	2,736
2020	4,079	3,974	2,906
Total	**39,658**	**38,891**	**31,682**

As shown in the above table, the fuel cost of option case 3 is 79 % and 81 % of that for case 1 and case 2, respectively.

10.2.6 CO_2 Emission

Appendices C.15 and C.16 show the classified annual generated energy per type of fuel and also the annual CO_2 emission in ton for the three option cases. Appendix C.15

shows that commissioning of combined cycle units in the expansion plan would remarkably reduce CO_2 emission. Total foreseen CO_2 emission in case of commissioning of combined cycle units is about 570 million ton, while it is about 598 million ton in option case 1 and about 582 million ton in option case 2. Figure 10.2-3 shows that commissioning of combined cycle units reduces the total CO_2 emission by 5 % on average over the expansion plan period comparing to option case 1 and about 2% comparing with option case 2.

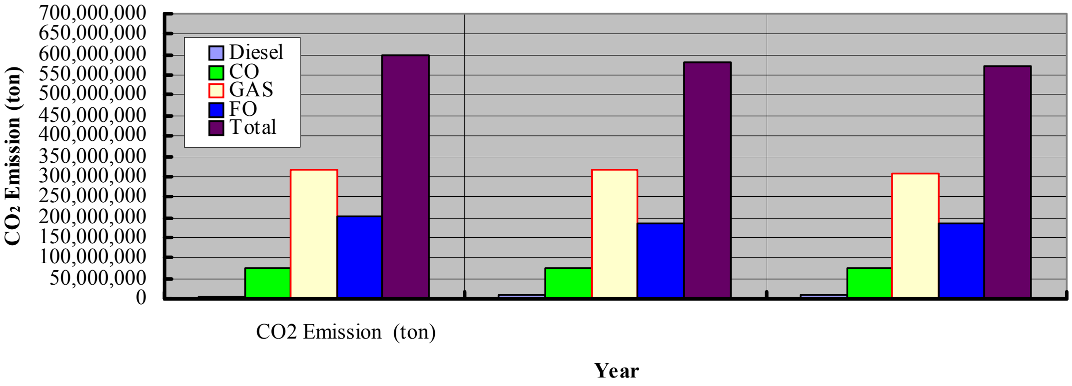


Figure 10.2-3 Total CO_2 Emission per Type of Fuel between 2006 and 2020

10.3 Power System Study

The power system at present is operated with load shedding and under low frequency and low voltage conditions. Under low frequency conditions, vibration in steam turbines may increase and some resonance problems in turbine low pressure blades may occur if the system frequency coincides with the resonant frequency of the turbine blades. Steam turbines allow for variation of the system frequency of ±0.5Hz from the rated frequency. Further, the low system frequency degrades the performance of auxiliary equipment which results in decrease of the power plant output.

Under low voltage conditions, electrical equipment in factories and homes is influenced. From the viewpoint of power system operation, low voltage operation causes increased loss in the transmission lines and a decrease of the transmission line capacity and steady state stability limits of the interconnected transmission lines.

Power system analysis is conducted to check such system conditions.

10.3.1 Power Flow Calculation Conditions

Since the recent conflict, MoE has been making efforts to restore the damaged transmission lines. Most of the damaged important lines have been restored, but some lines are still under repair.

A power flow calculation was conducted with the estimated potential demands at the respective governorates as mentioned in Chapter 6. Actual demands at the grid substations are not available and therefore the demands at the respective 132 kV substations have been roughly estimated. Equipment parameters for the system have been taken from the data sheets in the Needs Assessment report.

However, the exact conditions of the transmission lines are not available since information collected from several sources has not always been consistent. Accordingly, parameters for the power flow analysis have been prepared based on some assumptions. The final model should be confirmed based on the actual system equipment parameters.

In this study, only the power flow was calculated for the year 2004 and 2020 to check the grid substation bus voltage level and transmission line current capacity.

10.3.2 Power Flow in 2004

The power network diagram for the power flow calculation is referred to in Appendix I. Total power demand in 2004 was estimated at about 6,000MW in peak time. The system is still separated into two systems; one in the northern governorates of Erbil and Sulaymaniyah for which the 132 kV grid is operated separately from the main power system, and the other in the Iraqi main grid which interconnects the whole country (except the above governorates) with a 400 kV and 132 kV grid system. Interconnection with the neighbor countries, Turkey and Syria, is considered as a power source. All units in the power plant are assumed to be in an operable condition. Accordingly the total available generation capacity in the simulation is much larger than the present actual power demand.

The power flow in respective areas is known as follows.

i. The voltage level of the northern isolated system at the power stations is lower than the limit of acceptable voltage drop and this is mainly caused by a deficit of reactive power at peak load.

ii. 132kV bus voltages in the west region substations are higher than the system voltage due to light load and long transmission lines.

iii. Some 132 kV grid lines, of which the conductors are 150 mm^2 copper in the Baghdad area, exceed their transmission capacity.

iv. Except for the above, the bus voltage at the 132 kV grid substations and the current capacity of the transmission lines would be maintained within tolerance.

Except for the above, the system would be operated within the normal operating conditions.

The power flow calculation result in 2005 is shown on the Figure 10.3-1 and 10.3-2, respectively.

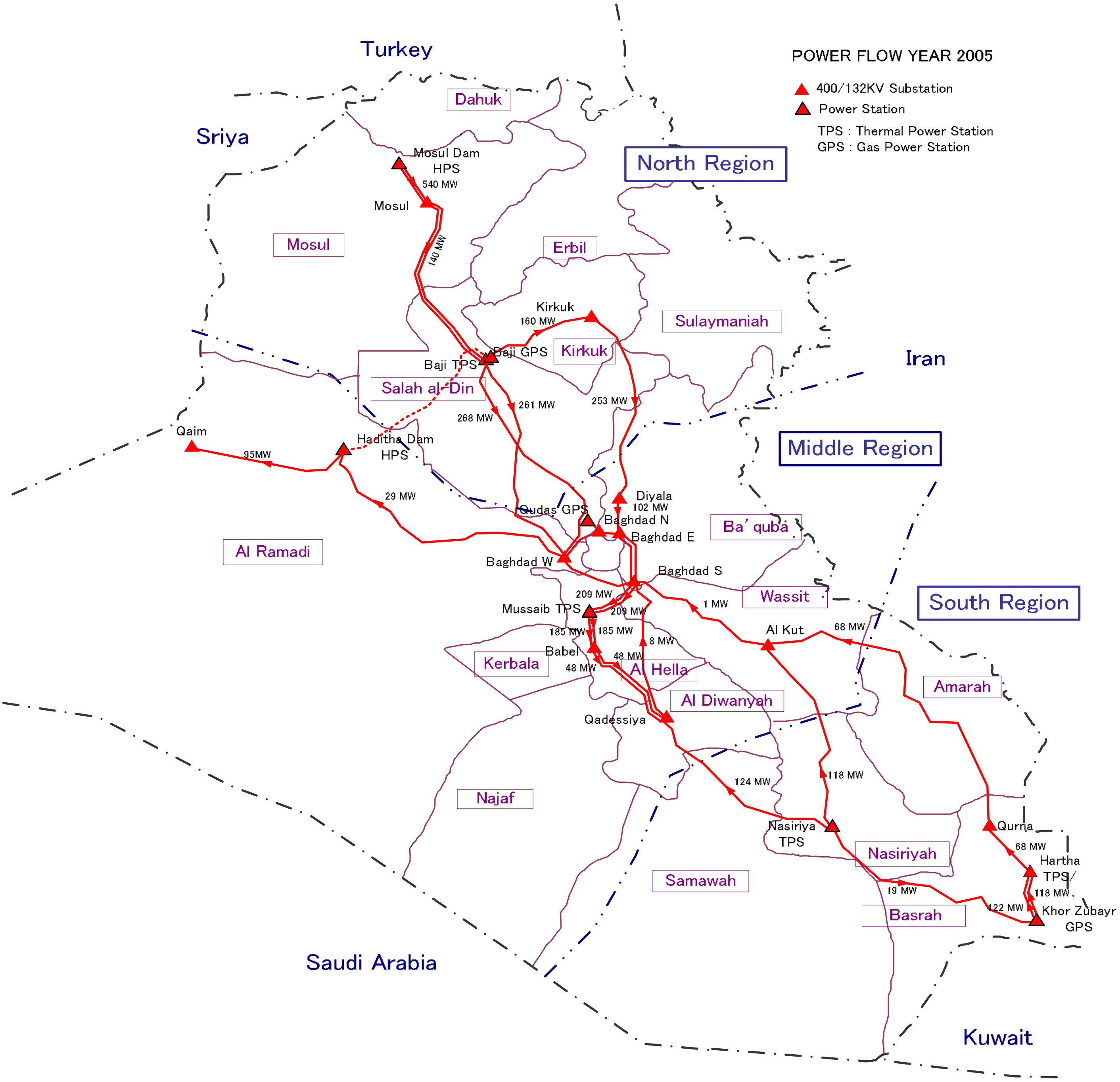


Figure 10.3-1 Power Flow in Year 2005 (400 kV)