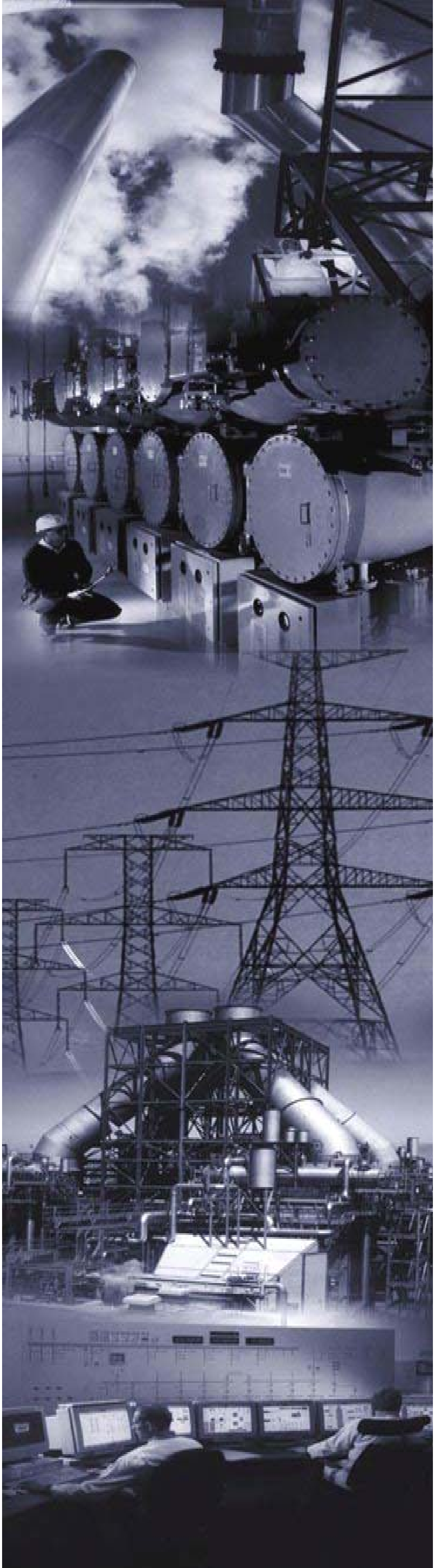

REPUBLIC OF IRAQ

MINISTRY OF ELECTRICITY

IRAQ ELECTRICITY MASTERPLAN

FINAL REPORT

VOLUME 1

EXECUTIVE SUMMARY

DECEMBER 2010

PARSONS BRINCKERHOFF

Dedicated to the memory of

Terry Barnich

6 March 1953 - 25 May 2009

Without whose foresight, vision and drive, this project would not have been possible

IRAQ ELECTRICITY MASTERPLAN

Overall Table of Contents

LIST OF REVISIONS						
Current Rev.	**Date**	**Page affected**	**Prepared by**	**Checked by (technical)**	**Checked by (quality assurance)**	**Approved by**
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REVISION HISTORY	
1	Correct Figure 8 inserted. Typographical errors corrected.
0	Masterplan Final Report

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Glossary

Exchange rate $US 1 – 1170 ID

AAC	All aluminium conductor
ACSR	Aluminium conductor steel reinforced
Amp	Ampere – unit of electrical current
ASPEN	Protection software
bbl	Barrel
BSP	Bulk Supply Point
C	Centigrade
CC or CCGT	Combined Cycle Gas Turbine
CYMDIST	Distribution analysis software written by CYME
DC	Double circuit
EHV	Extra high voltage
GCal	Giga-Calorie – 10^9 calories (energy unit)
GDP	Gross Domestic Product
GE	General Electric Company
GJ	Giga-Joule – 10^9 joules = million kCal (energy unit)
GSP	Grid Supply Point
GT	Gas turbine (= Combustion turbine)
GW	Gigawatt
HFO	Heavy Fuel Oil
Hz	Hertz = cycle per second (unit of frequency
IAEA	International Atomic Energy Agency
IEA	International Energy Agency (Paris)
IEK	Iraq excluding Kurdistan
ID	Iraqi Dinar
IHSES	Iraq Household Socio Economic survey
IPP	Independent Power Project
kA	Kilo Amp
kV	Kilo Volt
kWh	Kilowatt hour – sometimes called a unit of electrical energy
LDC	Load Duration Curve
LRMC	Long Run Marginal Cost
LV	Low voltage
ME	Ministry of Electricity
MMBTU, mmBTU	Million British Thermal Units
MMSCF	Million Standard Cubic Feet

MO	Ministry of Oil
MUSD	Million US dollars
MV	Medium Voltage
MVA	Million Volt Ampere
MW	Megawatt (million watts) – unit of power
NPV	Net Present Value
ONAF	Oil Natural Air Forced (transformer cooling option)
PB	Parsons Brinckerhoff
PSSE	Power System Simulator for Engineering - power systems analysis software
PV	Present Value
RM	Reserve Margin
SC	Single Circuit
SCADA	Supervisory Control and Data Acquisition
SCF	Standard Cubic Feet
SRMC	Short Run Marginal Cost
ST	Steam Turbine
TCF	Tera cubic feet (10^{12})
USc	US Cent (100 to 1 US$)
US$	US Dollar
WASP	Wien Automatic System Planning
“	inch

1. INTRODUCTION

This Executive Summary is the first volume of the five that comprise the Iraq Electricity Masterplan study. It summarises the four subsequent volumes, which cover load forecasting, generation planning, transmission planning (short and long-term), and distribution planning. The Iraq Electricity Masterplan considers the period 2010 to 2030 and covers Iraq excluding the Kurdistan region.[1]

The study was financed by the US Government State Department and executed under the supervision of the State Department's Iraq Transaction Assistance Office (ITAO). A Steering Committee was formed to oversee the study, comprising members from ITAO, ME and Parsons Brinckerhoff (PB).

The study commenced with an initial kick-off meeting in Erbil in December 6th 2009. Data gathering and condition assessment visits were made to major power stations and the seven BSP distribution areas. Data was also sourced from the ME in Baghdad and the regions, and load measurements were also made. PB carried out the studies using a combination of Baghdad and UK-based staff and worked in close collaboration with the ME's Masterplan team, who made an invaluable contribution to the Masterplan. The ME team members are shown in Table 1. Workshops, presentations and discussion meetings were held in Erbil and Baghdad as part of ME capacity building, and details of the programmes for the four main parts of the planning are given in each report volume. The aim of the capacity building was to ensure that the ME Master Plan staff would be able to update the Masterplan studies in subsequent years, and hands-on training was an integral part of the process. Software and text books were also provided.

Distribution planning was not carried out for the whole of Iraq, since this would be a very large enterprise that would require a great amount of local data collection and analysis, and would be best carried out by ME's distribution staff. To this end capacity development was given to ME staff from each of the seven Distribution Directorates, and detailed distribution planning was carried out for the areas supplied by a Bulk Supply Point substation in each area. An expandable distribution planning laboratory was supplied to the ME headquarters in Baghdad, using CYMDIST, a popular distribution planning software package. Additionally, stand-alone CYMDIST workstations were provided for use in each of the seven distribution directorates.

An overall summary is given in Section 2, and the conclusions and recommendations relating to generation, short and long term transmission, and distribution are given at the end of each relevant section.

A SCADA Masterplan and a Grid Code are also being developed for the ME by PB under US Government State Department (ITAO) funding, and will be issued separately in 2011.

[1] The Kurdistan electricity system was the subject of a Masterplan study carried out by PB in 2009 for the Kurdistan Ministry of Electricity

Table 1 Master Plan Team

	Team Leaders	Title in the Master Plan Team	Position/Department in the ME
1	Dr. Kosay Abd Al Sattar	Supervisors	D.G of Planning & Studies Office
2	Mahdi Dahham Jasim	Project Manager	Assistance D.G of Planning & Studies Office
3	Basem Hattab Meshatat	Manager of Studies Department	Planning & Studies Office
4	Abdulkadhim Fadel Abbas	Manager of Transmission Department	Planning & Studies Office
5	Nooria Abd Mohammed	Manager of Economic Studies	Planning & Studies Office
6	Mohanned Mamoon Mahmood	Senior Chief Engineer	Planning & Studies Office
	Participant Members		
1	Mohammad Ali Jaber Mustafa	Expert	Planning & Studies Office
2	Kamal Ibrahim	Expert	Energy Production Office
3	Ali Adel Abdulmohsan Hassan	Engineer Senior	Planning & Studies Office
4	Abd Habeeb	Engineer	Operation & Control Office
5	Hazim Klwana Hana Mohammad	Senior Chief Engineer	Energy Transmission Office
6	Shewkat Jasim	Senior Engineer	Energy Distribution Office
	Support Members		
1	Directorates of Distribution		
2	Directorates of Transmission		
3	Directorates of Generation		
4	Operation and Control		

2. OVERALL SUMMARY

The people of Iraq are suffering considerable shortages in electricity supply, which are also greatly affecting the economy. The cost to the economy from un-served energy is estimated in the generation planning studies to be about US$40 billion per year at present.

The ME has a committed plan for the installation of nearly 13 GW of new generation over the next five years. About 10 GW of this generation is gas turbines (GTs) ordered through the MegaDeal contracts with GE and Siemens. It is obviously extremely important that all the committed plant is installed and commissioned in a timely fashion. If the committed generation is commissioned to schedule there will be sufficient capacity to meet the demand of Iraq with adequate reserve by 2013 or 2014. This also requires, however, the parallel development of fuel supplies to the power stations, transmission connections to the grid and grid development. Considerable co-operation between the ME and the MO is essential.

Gas is the economic and environmental fuel of choice, and conversion of power stations running on crude oil and gas turbines running on heavy fuel oil (HFO) to gas is also a priority. In the longer term combined cycle (CC) power stations, comprising gas turbines with waste heat boilers feeding a steam turbine, are the most economic option. Conversion of GTs running on gas to CC operation and adding new CC plant is the optimum economic plan, with large GTs to supply additional peaking power later in the 2010 – 2030 period. Note that peak demand is predicted to rise from around 11 GW at present (Iraq excluding the Kurdistan region) to about 32.5 GW by 2030 in the Base Case forecast. Additional thermal plant above that taken as committed in the studies (see Table 6) is not recommended as it is less economic, whether fired on crude oil, HFO or gas, and provided that GT and/or CC plant can be built instead.

Transmission system development must accompany the generation development, and ME have a short term plan for both the 400 kV and 132 kV systems. Re-configuring the 132 kV systems, particularly in the Baghdad area, is also very important to overcome high fault level problems. In the longer term it is recommended that the 400 kV and 132 kV systems are further developed, accompanied by some bulk gas transfer particularly towards Baghdad. The use of high capacity 400 kV transmission lines is recommended, using four conductors per phase, both in the short and long term developments.

The distribution system needs considerable rehabilitation and development to meet the existing and future demands. Distribution planning guidelines and standards have been provided for development of the 33 kV and 11 kV distribution systems, and planning software and training provided, including detailed planning with ME's engineers for seven Bulk Supply Point areas distributed throughout Iraq.

The overall cost of the development of the electricity sector is very large, but the economic benefits will pay back the investment many times over, accompanied by a considerable improvement in the life of the people of Iraq. Overall the investment in the next five years to implement the committed plans will be about US$26 billion, allowing about US$ 10 billion for the short-term generation. After that the investment required will average about $US 4 billion per year. Some of the generation investment could come from independent power plants (IPPs) with the pay back being through the electricity payments to the IPPs.

3. LOAD FORECASTING

3.1 Approach

This section summarises the load forecasts between 2009 and 2030 for Iraq, excluding Kurdistan, which we have called IEK. Kurdistan is made up of the Governorates of Dohuk, Sulaimaniya and Erbil. A full explanation of the load forecast methodology is given in the subsequent sections of this report.

The draft load forecasts (Base, Low and High) were described in a report dated 12 March 2010. Following a presentation, review and discussions with ME, final overall load forecasts were produced, and are presented in this report. The principal changes were to include the effects of a tariff increase and to revise the GDP growth rates of some of the sectors whilst retaining the overall GDP growth rates of Iraq. The final load forecast report was discussed with the ME during a meeting in Erbil on Sunday 26th March where it was accepted and agreed that it could be used for the planning in the Masterplan.

The draft load forecast report also included a distributed forecast by 132 kV bulk supply points, based on the overall load forecast. The distributed forecast is used in transmission and distribution planning. The ME advised that they would supply a revised list of large loads, and this was used to revise the distributed forecast based on the overall forecasts.

The load forecasts are the result of a combined study by PB and the ME load forecasting team, with the ME team providing valuable input on local conditions and PB using its experience to provide structure, methodology and international comparisons.

The team started by looking at the present electrical system in Iraq and used 2009 substation data and reports to estimate a non-suppressed demand at the generation sent-out level of about 11,466 MW.

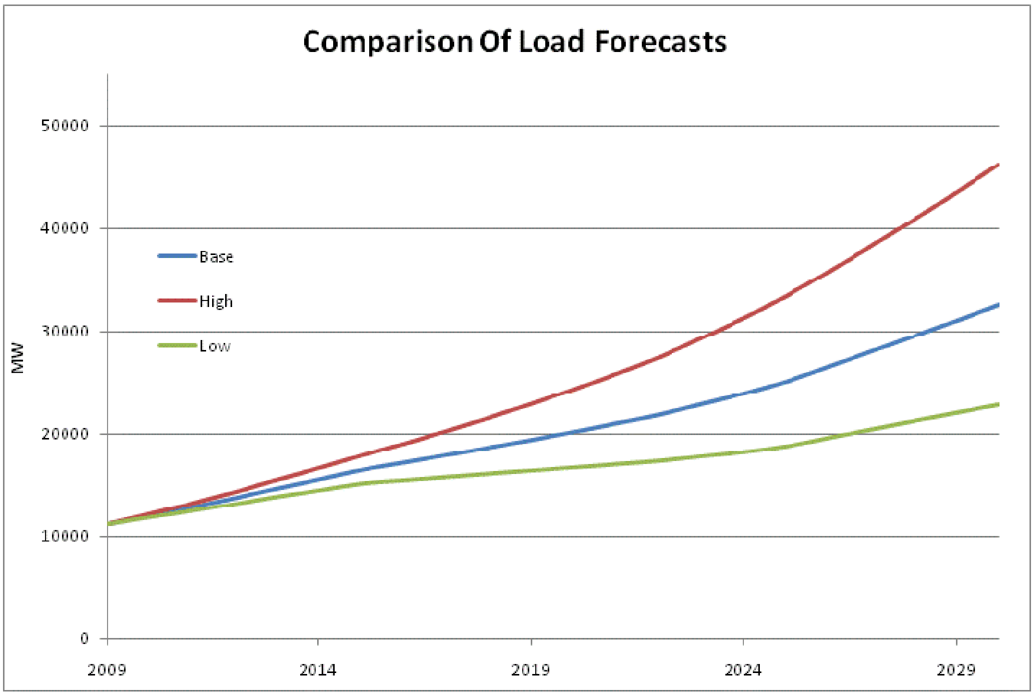
An estimate of existing load was also developed using a “Bottom Up” approach. This gave a sent-out generation demand of about 13.4 GW for all Iraq and about 11.2 GW for IEK. These figures are similar to the IEK suppressed demand estimate from the substation analysis described above, and also to the maximum demand for all Iraq from a prior econometric study carried out by PB and the ME study team. We thus have a degree of confidence that the demand forecast starts off from a reasonable estimate of unsuppressed demand.

We then looked at the economic prospects for Iraq, and came to the conclusion that there is likely to be an extended period of economic growth of around 7% per annum in real GDP. The Base Case load forecast was then derived using a “bottom-up“ approach based on sectorial GDP growth and income and price elasticities to relate electricity demand growth by sector to GDP growth. Table 1 gives the resulting Base Case forecast, and Figure 1 compares the High, Base and Low forecasts.

Table 2 Base Case Load Forecast for IEK - MW

	Domestic	Commercial	Industrial	Governmental	Agricultural	
2009	6162	1333	1889	1802	63	11248
2010	6618	1440	2027	1933	64	12083
2011	7068	1549	2167	2067	66	12918
2012	7542	1663	2312	2205	69	13791
2013	8054	1776	2470	2355	74	14729
2014	8562	1909	2649	2401	80	15600
2015	9101	2061	2828	2447	86	16524
2016	9456	2177	3009	2494	93	17229
2017	9825	2299	3190	2542	100	17956
2018	10208	2418	3373	2591	108	18698
2019	10606	2537	3555	2641	115	19454
2020	11020	2654	3749	2692	123	20237
2021	11450	2768	3956	2743	131	21047
2022	11896	2878	4177	2796	138	21886
2023	12467	2985	4453	2858	146	22908
2024	13043	3086	4741	2919	153	23942
2025	13727	3210	5040	2980	160	25117
2026	14628	3386	5345	3040	167	26566
2027	15537	3573	5647	3097	174	28028
2028	16460	3769	5951	3154	180	29514
2029	17393	3976	6253	3208	187	31018
2030	18332	4195	6553	3261	194	32535

Figure 1 High, Base and Low Case Load Forecasts



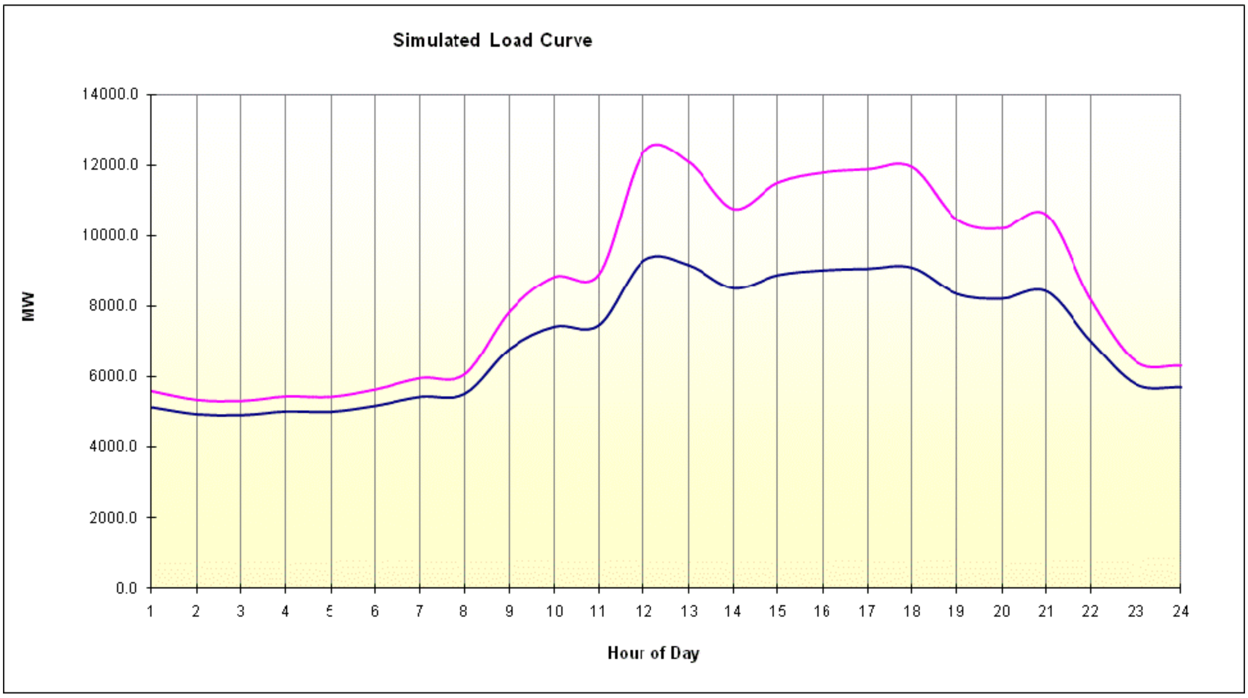
A forecast of the demand from consumers not connected at present to the ME system was also derived, estimated to be just less than 40 MW in 2020.

Finally, and as a third check on un-suppressed demand, we determined a series of load curves for weekdays, Fridays and Saturdays, for:

- Each Governorate and IEK as a whole, and
- For four seasons. These have been defined for study purposes as:
    - Winter: December, January, February;
    - Spring: March, April;
    - Summer: May, June, July, August, September
    - Autumn: October, November.

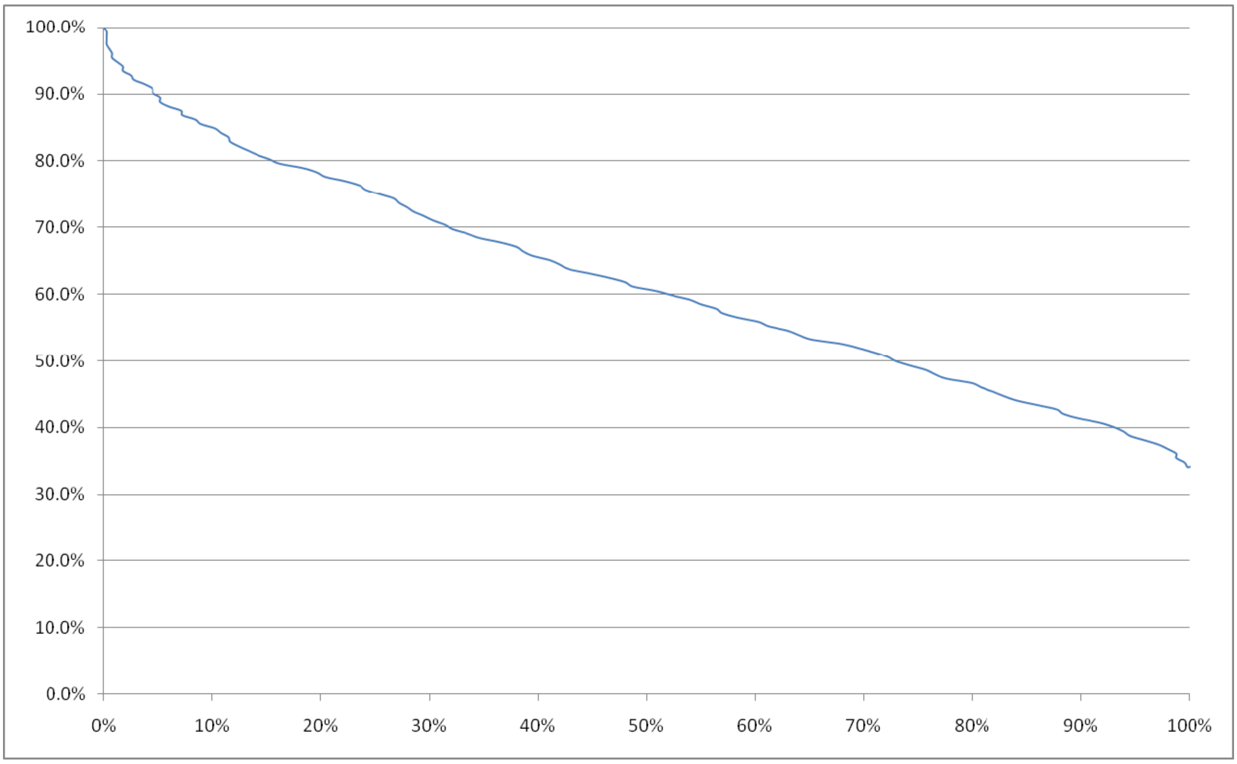
The load curves were based upon appliance ownership, as defined in the 2008 Iraq Household Socio-Economic Study (IHSES), and the daily use patterns of these appliances. These daily use patterns were based on the judgement of some Iraqi residents and should be firmed up in future by the ME carrying out a usage survey among domestic consumers. Figure 2 shows an example of the expected peak demand daily load curve generated by this modelling. The lower curve represents demand at the consumer level whilst the upper curve is sent-out demand at the generation level after power losses have been incorporated.

Figure 2 Summer Weekday Load Curve for IEK



By taking weighted averages of the week and weekday demand we have produced load duration curves for each season, which are required as an input to WASP. Figure 3 shows the annual load duration curve for Iraq excluding Kurdistan using this methodology. Iraq's unsuppressed demand is predicted to have the relatively high annual load factor of about 68%.

Figure 3 Annual Load Duration Curve for IEK



4. GENERATION PLANNING

4.1 Introduction

The generation planning analysis for Iraq has been carried out using the WASP least cost analysis computer program supplied by the IAEA, and used by the ME Planning Department. The studies exclude the Kurdistan region[2].

The main studies have been carried out for the period 2010 to 2030 using the Base load forecast, but with sensitivity studies for the High and Low load forecasts. The High forecast plan has been used in the long-term transmission planning studies. The starting point for the studies has been the existing and firmly planned generation (including the Mega Deal GTs).

Data collection was carried out by PB's Baghdad team and the ME Masterplan team, and included condition assessment site visits to major power stations.

The analysis has been carried out in full co-operation with the ME Masterplan team, and three week-long interactive workshops were held in Erbil. ME has been given working computer models of the final WASP runs and the working spreadsheets and files.

The analysis was subject to a data freeze at the end of March 2010, and the Final Generation Report was submitted in August 2010 followed by a presentation in Baghdad.

The close involvement of ME means that their planning team will be able to carry out updates of the generation planning on a regular basis (annually recommended). The updates will be able to take into account how load growth progresses, fuel supply developments, the latest status of existing and planned generation, and transmission system developments.

4.2 Fuel

Iraq has huge hydrocarbon resources (Figure 4), with proven crude oil resources of 115 billion barrels and proven natural gas reserves of 112 trillion cubic feet (TCF). About 70% of the gas reserves lie in Basrah governorate. Probable hydrocarbon reserves are much higher, with an estimated additional 45 to 100 billion barrels of recoverable oil in the southern and western deserts, and probable total gas reserves of 275 – 300 TCF.

Iraq plans to considerably increase its production of these resources from a relatively low base, as indicated in Table 3. Considerable quantities of associated gas are flared at present, estimated at about 650 million SCF/day in 2009, but Iraq has plans to gather and use this gas.

[2] See Kurdistan Masterplan for the Electricity Sector, PB, November 2009

Figure 4 Existing Hydrocarbon Resources in Iraq

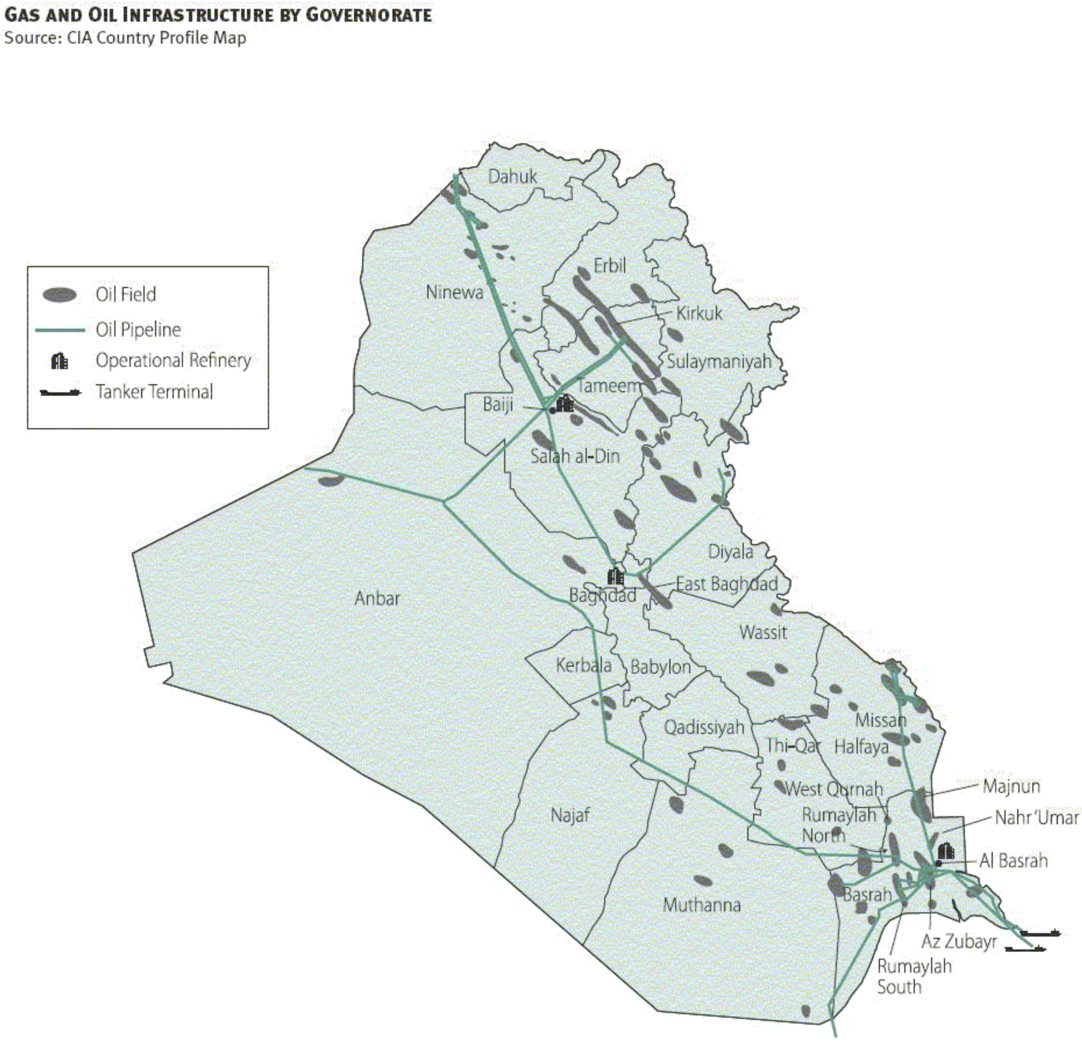


Table 3 MO Forecast of Crude Oil and Gas Production

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Crude Oil Production	million Bl/d	2.7	3.1	3.3	3.7	4.1	5.0	6.5	7.7	10.5	12.5
Associated Gas Production	million SCF/d	1500	1736	1980	2220	1460	3500	4550	5390	7350	8750
Dry Gas Production	million SCF/d	960	1390	1530	1810	2200	2800	3640	4312	5880	7000
Approx available for power production (1)	million SCF/d	823	1191	1311	1551	1886	2400	3120	3696	5040	6000
(1) Based on ratio 6000/7000 - rest for industrial / domestic use											
Source: Supplied by ME 10/05/2010 from MO document											

There are three major oil refineries at Baiji, Basrah and Doura, and several smaller refineries which are planned to be retired by 2015. New refineries with increased production are planned from 2015 to 2017.

The estimated amount of heavy fuel oil (HFO) available is given in the table below.

Table 4 HFO Available for Power Generation

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
HFO Production (1)	m3/day	41,000	48,000	52,000	51,000	49,000	57,000	59,000	59,000	59,000	59,000	59,000
Estimated High Sulphur (6%)	m3/day	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Estimated 3% Sulphur HFO	m3/day	37,000	44,000	48,000	47,000	45,000	53,000	55,000	55,000	55,000	55,000	55,000
Industry use (2)	m3/day	5,000	5,350	5,725	6,125	6,554	7,013	7,504	8,029	8,591	9,192	9,836
Available for Power Generation	m3/day	32,000	38,650	42,276	40,875	38,446	45,987	47,496	46,971	46,409	45,808	45,164
Available for Power Generation	tonnes/day	30,400	36,718	40,162	38,831	36,524	43,688	45,122	44,623	44,089	43,517	42,906
Notes:												
(1) Source: Presentation by MOO on 15/06/10												
(2) Escalated at 7% per annum in line with GDP growth 2011 onwards												

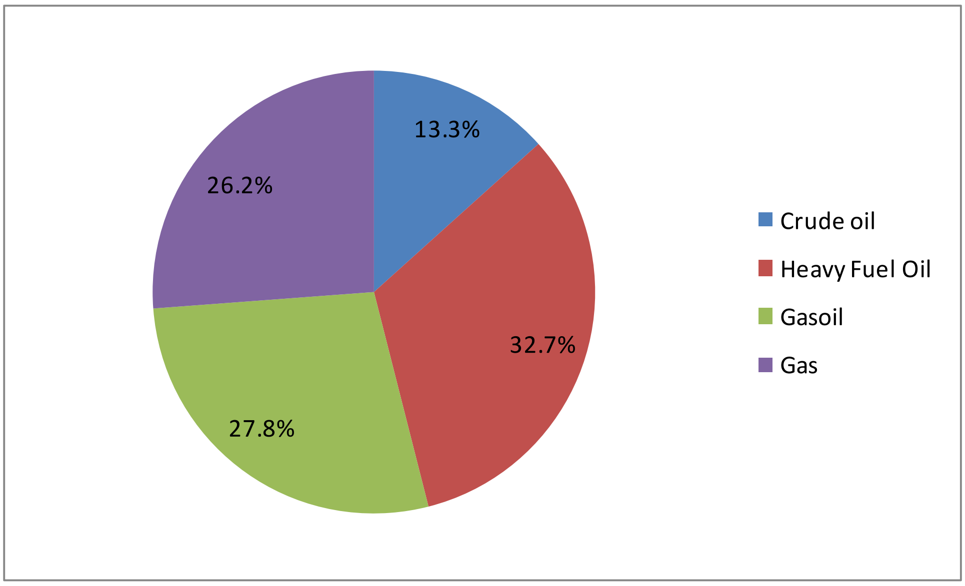
Figure 5 shows the estimated percentage fuel burn (based on total GCal) for electricity production in 2009 (estimated from the generation planning modelling – metered values not available). These correspond to an estimated average gas burn of 430 millions SCF/day and 15,000 tonnes/day of HFO. The notable points are:

- The large crude oil burn (28% of total fuel energy) - this is very expensive to the Iraqi economy in terms of lost export income.
- 13% of the fuel energy comes from gasoil, which is a premium and expensive fuel (partially imported).
- Heavy fuel oil and gas provide about 33% and 26% of the energy respectively.

The gas burnt is only about a half of the available fuel according to Table 3 – but this assumes that flared gas is processed and available. This flared gas would be sufficient to power about 4GW of combined cycle base load plant. The HFO burnt is also only about half the amount available – in this case the HFO is mixed with crude for export, or disposed of in other ways.

It should also be noted that considerable amounts of gasoil and crude oil are being burnt. Both of these are expensive fuels – gasoil is a premium fuel and has to be partly imported, and crude oil burnt in power stations could otherwise be exported, and thus has a high value.

Figure 5 Fuel Burn for Electricity Production in 2009



The fuel prices used in the planning have been based on economic pricing rather than domestic market prices. Economic prices represent the resource costs to the Iraq economy of using the fuels. It is the economic price, not the market price, which should be used in planning since the market price represents only the cost to the utility whereas the economic price represents the cost to the country. As an example, the cost to the economy of using crude oil for generation is the revenue foregone by not being able to sell this oil on the international market, whereas ME pays a highly subsidised price.

The crude oil and gasoil prices used in the planning have been based on market prices of 80 US$/bbl for crude oil, and a corresponding gasoil price of 585 US$/tonne. The 117 US$/tonne price of 3% HFO has been based on an export netback price i.e. by subtracting transport costs from the market price. The gas price for power generation has been based on an LNG export netback price, taking into account the costs of liquefaction and transportation of the gas if it were exported, and amounts to 4.5 US$/million BTU.

4.3 Existing and Committed Generation

The starting point for the generation planning is the existing and committed generation plant. By committed we mean generation plant that ME have firmly decided to build or have signed contracts.

The capacity and availability of the existing plant was estimated by examining daily Station Reports for 2009 and from the Condition Assessments. The relevant capacity is that for peak temperatures i.e. in August. The other important factor is the retirement schedule for plant, which was based on the dates of commissioning and rehabilitation, and their condition.

Table 5 shows the capacity of the existing plant at key dates used in the planning.

Table 5 Capacity of Existing Plant 2009 – 2030

Maximum Capacity MW (45C) - All Plant Available					
	2009	2015	2020	2025	2030
GTs and Steam	6740	4284	1922	1084	1084
Interconnectors (Iran)	700	700	700	700	700
Hydro and Pumped Storage	1757	1757	1757	1757	1757
Total	**9197**	**6741**	**4379**	**3541**	**3541**

It should firstly be noted that the total capacity in 2009 is much less that the total nameplate rating, due to plant de-ratings and the temperature of 45°C. Secondly, it is considerably more than the maximum generation in summer 2009. This is due to several factors:

- Low availability of plants (maintenance and forecast outage);
- Hydro capacity being below maximum output due to water shortages / unit outages;
- Pumped storage not being used at peak (not worthwhile with a shortage of generation).

The other item to note is how, due to retirements, the capacity drops by a third by 2015 and two-thirds by 2025.

Table 6 summarises the total committed capacity that is being added to the Iraq system. Two scenarios have been considered, the first with the ME plan for commissioning the Mega Deal GTs being to schedule, and the second with one to two year delays, with completion in 2016. The committed capacity is made up of not only a large amount of GTs, notably from the GE and Siemens Mega Deals, but also a significant amount of thermal (steam) plant, diesels and a small hydro plant (Adhaim).

A particularly significant feature is that the amount of committed capacity is such that with the existing capacity the unsuppressed demand of Iraq will be satisfied by 2013 to 2014 if the plan is realised.

Table 6 Committed Generation Capacity

		Sent-out	
Committed GTs in ME Short-term Plan	15C	45C	45C
ME Re-powering Project	600	507	
GE Fast Track	660	510	
GE MegaDeal	6500	5272	
Siemens MegaDeal	3190	2821	
Total	10950		9110
Diesels			
Hyundai Diesels	360		288
Committed Thermal			
Hartha 2 and 3 Rehab		376	
Hartha Extension		553	
Wassit		1216	
Yussifiyah		580	
Nasiriyah Extension		553	
Total			3278
Other Projects (642 MW)			
Sadr Sunior GTs		247	
Akkaz GTs		96	
Haditha Pielstick Diesels		200	
Huriyah Diesels		72	
Adhaim Hydro		27	
Total		642	642
New Interconnector		550	550
GRAND TOTAL			**13868**

4.4 Candidate Plant

Various types of plant and fuels were considered to provide new capacity to meet demand after the completion of the committed plan in 2016. A screening curve analysis was used to narrow down the choices entered into the WASP generation planning program. The screening curves compared the through life cost of generating electricity (investment, fuel and operations and maintenance) at different annual load factors.

Table 7 gives the short-listed plant.

Table 7 Short-list of Candidate Plants Studied in WASP

Type	Rating MW	Fuel	Notes
Gas Turbine	200	gas	
Combined Cycle	600	gas	
Thermal (steam)	300	HFO	
Thermal (steam)	350	HFO	
Thermal (steam)	600	HFO	Supercritical boiler

4.5 Recommended Generation Plan

A considerable number of generation planning runs were carried out using WASP. With the implementation of the committed plan, there will be an excess amount of peaking plant on the Iraq system (GTs, storage hydro and pumped storage) and insufficient base and mid-merit capacity (CC, thermals, diesels on HFO). The absolute least cost planting programmes from WASP selected large amounts of CC plant to overcome this and save fuel cost – so much so that much more capacity would be installed than needed to provide supply security. This was not considered realistic, however, because of the high investment cost and large amount of capacity that would be installed. The planting programmes were therefore constrained to meet the generation system reliability of supply target in subsequent WASP runs. The resultant recommended least cost programme is shown in Table 8 below. Significant points to note are:

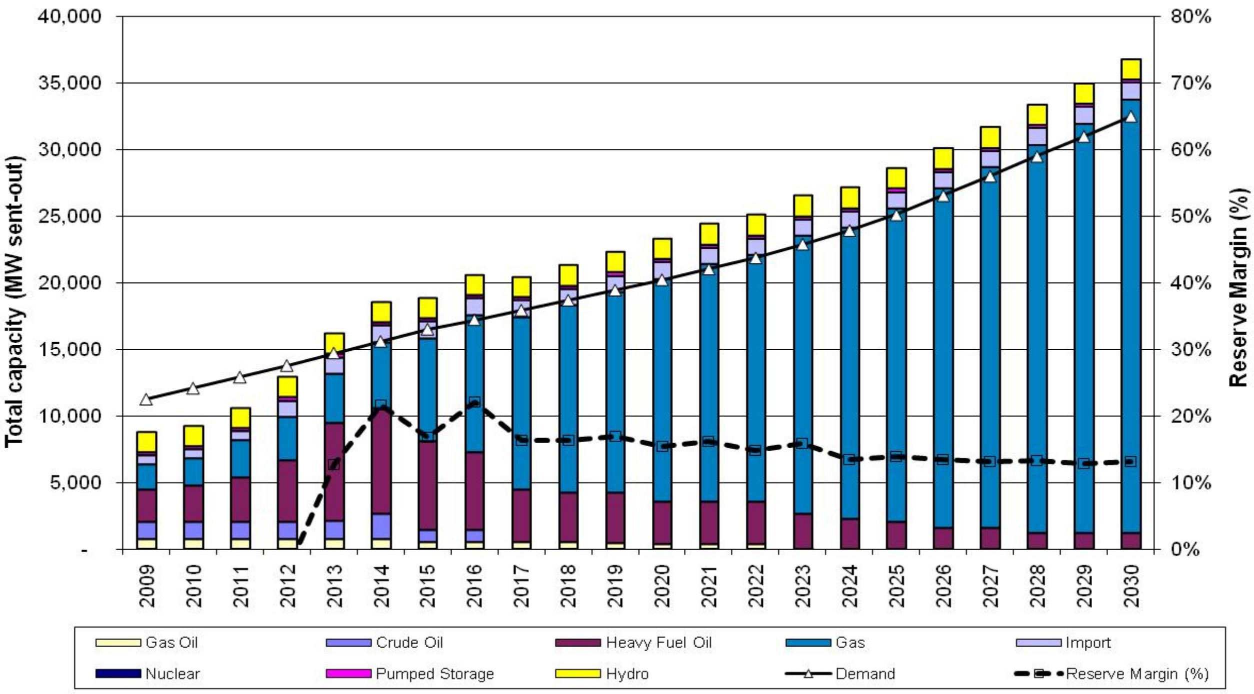
- The first additional capacity is not required until 2017 (Base Load Forecast)
- The conversion programme of single cycle GTs (mainly MegaDeal) running on gas to combined cycle
- The addition of 600MW CC plants (29 by 2030)
- 200MW GTs are installed from 2024 onwards – this shows that the system has neared an optimum economic mix of plant by that date.

Table 8 Recommended Generation Plan

Year	Cumulative Additional Plant (from Candidates)				
	200 MW GT New - gas	600 MW CC New - gas	282MW CC Conversion of 2xF9E - gas	600MW CC Conversion of 2xV94.3 - gas	355 MW CC Conversion 2xV94.2 - gas
2015					
2016					
2017				2	3
2018		1	3	2	5
2019		2	9	2	6
2020		4	19	2	6
2021		5	27	2	6
2022		6	28	2	6
2023		10	28	2	6
2024	4	11	28	2	6
2025	4	14	28	2	6
2026	7	17	28	2	6
2027	7	20	28	2	6
2028	9	23	28	2	6
2029	9	26	28	2	6
2030	10	29	28	2	6

Figure 6 shows the capacity installed by fuel type, the Base Case load forecast and the reserve margin (percentage of capacity above the maximum load).

Figure 6 Recommended Generation Plan – Capacity and Demand



As discussed earlier, it can be seen that there would be sufficient capacity by 2013 to meet demand, assuming the installation of the committed generation is to schedule.

It can also be seen that up to 2013/14 the amount of capacity burning HFO and crude increases, but subsequently declines, and the proportion of gas-fired plant rapidly rises to dominate the capacity. The increase in gas-fuel plant initially arises due to a conversion programme of GTs to gas-firing, and later due to the conversion of the single cycle gas-fuel GTs to combined cycle and the installation of new GT and CC plant using gas.

The recommended fuel conversion program is shown in the table below:

Table 9 Recommended Fuel Conversion Programme

Fuel Conversion from Crude Oil
–Run Wassit new Thermal Plant on gas rather than crude (2014)
–Existing Hartha Thermal Units 1 & 4 to HFO (2013)
–Existing Qudus 6xF9E GTs to gas (2015)
–GE Megadeal: Qudus 4x and Wassit 4x F9E GTs (2015)
–Committed Yussifiyah 3x210 MW Thermal run on gas (2017)
Fuel Conversion from HFO to gas
–GE Megadeal: 42xF9Es (2015 -2017)
–Siemens Megadeal: 10xV94.2 (2015 -2017)

The conversion of plant running on crude oil is the priority because of the high cost of this fuel.

Although the conversion of GTs to CC is shown to be least cost, the actual savings are not major. An additional advantage of conversion is, however, that the number of power station sites required will be reduced.

However, the ME may decide that conversion of all of the Mega Deal GTs fired on gas (plus a few others) is not worthwhile due to the condition of the turbines. Installing brand new 600 MW combined cycle plants may be easier and more attractive. The ME should review the conversion programme in successive years, as the actual demand growth and plant installation program unfolds, to decide how many GTs it wishes to convert.

There are proposals by ME to install more thermal (steam) plants in the next few years than are included in the committed plant programme that has been studied. Some of these additional plants were only known after the planning had been completed – e.g. Khayrat. However the least cost planning runs have not selected thermal plant, confirming the results of the screening curve analysis which showed that they are more expensive overall. This is due to their high investment cost and their lower efficiency compared to combined cycle plant.

A case could be made, however, that if gas is not made available as quickly as promised, installing extra thermal plant would be advantageous. To this end, a scenario where gas availability was delayed by five years was considered using WASP. As expected, the overall present value was higher than the recommended plan (around US$ 5 billion more). The other significant result from these studies was that gas turbines running on HFO were shown to be more economic than thermal plant using HFO, in spite of their reduced availability and capacity and higher operating and maintenance costs relative to gas firing. This confirmed the screening studies which showed that thermal plant is slightly more expensive overall than GTs running on the same fuel at all plant load factors less than 80%.

Figure 7 and Figure 8 show the gas and HFO burn respectively for the Recommended Plan. The blue columns in Figure 7 show the MO forecast of gas availability up to 2019, which is the latest date in MO's projection. The red columns show the forecast of gas burn for electricity generation. It can be seen that if the gas availability follows MO's projection there will be a considerable margin between availability and use. However, it is recommended that gas for domestic use (power industry and residential) should take priority over export, to avoid the possibility of a shortage (as is currently being experienced by some Middle East gas exporting countries).

Figure 8 shows in blue the forecast of HFO available for power generation, derived from the MO's projection after the subtraction of industry use. In this case MO's forecast only goes as far as 2018.

Figure 7 Gas Burn MMSCF/day – Recommended Plan

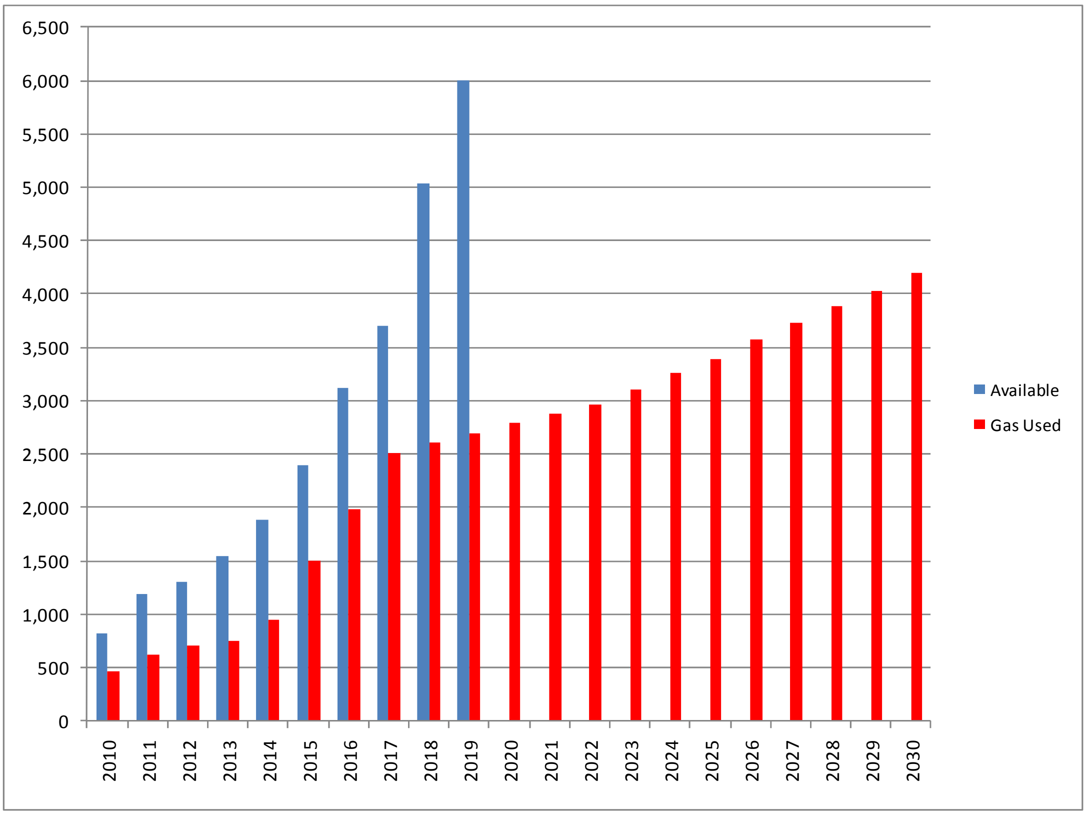
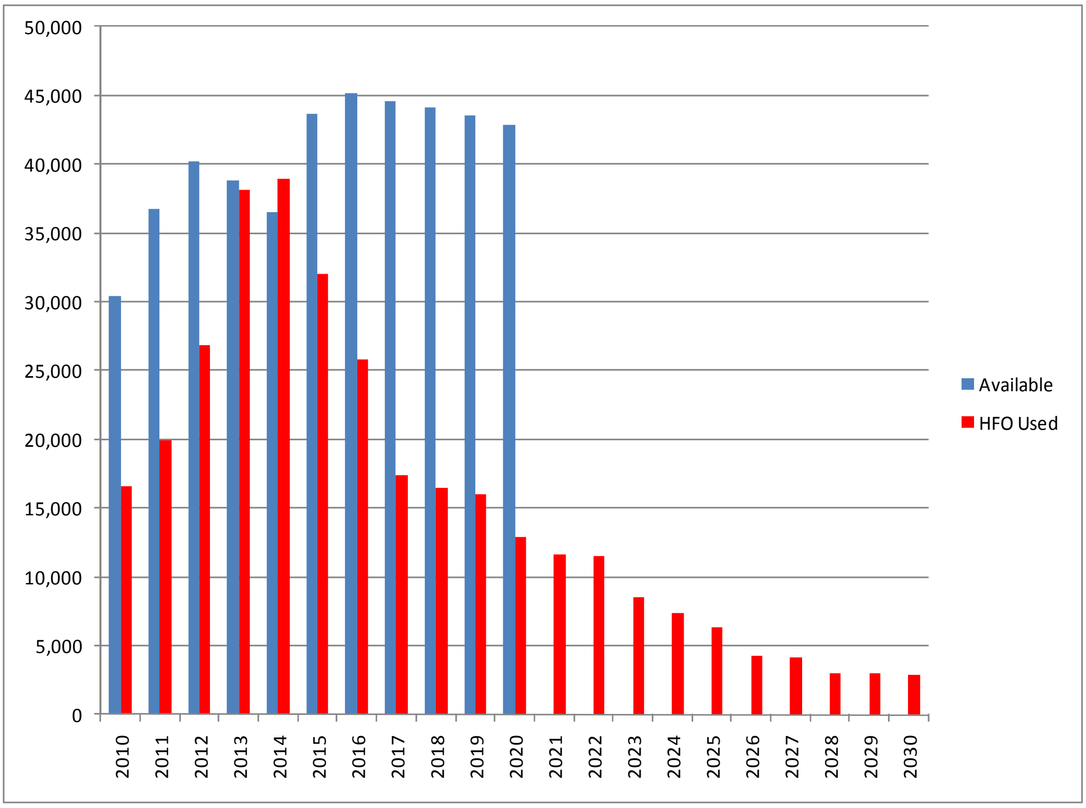


Figure 8 HFO Burn Tonnes/day – Recommended Plan



It can be seen that up until 2014 the demand for HFO rises rapidly, nearly reaching the available capacity. This results from the large number of GTs and thermal plants burning HFO that are installed in the committed plant programme. Subsequently they are converted to gas and the usage drops. A large surplus of HFO thus develops from 2015 onwards. Iraq is undergoing a programme of new refinery construction during the study period, and it is suggested that the overall least cost solution for Iraq is to construct the new refineries to produce less HFO and more premium fuels, such as gasoil and gasoline.

The table below gives investment cost of the recommended long-term generation plan.

Table 10 Investment Cost of Recommended Long-Term Plan – US$ Millions

Year	Investment Cost			Interest during Construction			**Total Investment**
	Domestic	Foreign	Total	Domestic	Foreign	Total	**plus IDC**
2015	83	333	416	4	16	20	**436**
2016	298	1,190	1,487	23	93	117	**1,604**
2017	338	1,355	1,693	30	121	152	**1,845**
2018	468	1,875	2,343	39	157	196	**2,539**
2019	510	2,042	2,552	51	204	255	**2,807**
2020	340	1,363	1,703	33	134	167	**1,870**
2021	331	1,325	1,657	26	105	131	**1,788**
2022	320	1,282	1,602	44	176	220	**1,822**
2023	374	1,498	1,872	28	113	141	**2,013**
2024	381	1,525	1,907	41	164	205	**2,111**
2025	461	1,844	2,305	46	184	230	**2,535**
2026	378	1,512	1,890	41	163	204	**2,094**
2027	431	1,725	2,156	44	177	221	**2,377**
2028	361	1,445	1,806	40	160	200	**2,006**
2029	204	817	1,022	31	125	156	**1,178**
2030	-	-	-	-	-	-	**-**
Total 2015 - 2030	5,281	21,130	26,411	523	2,092	2,615	**29,026**
Notes:	Money of 2009						

It can be seen that for new generation / conversion beyond the committed plan, about US$2 billion per year (money of 2010) is needed. The table shows a tail-off in 2029 and 2030 – this is due to the fact that the plant required beyond 2030 are not included (costs are disbursed in advance of commissioning). The total investment cost for generation from 2016 – 2030 will be about US$ 30 billion.

4.6 Conclusions and Recommendations from Generation Planning

1. Un-served energy cost is huge at present (US$40 billion). Delay in implementing the committed short-term plan will therefore be very costly to Iraq.

2. Gas is the economic fuel of choice.

3. The economic priority is to convert generators running on crude oil to gas (or HFO if gas is not available).

4. New GTs (predominantly MegaDeal) and the existing Qudus F9E GTs should be converted from burning crude or HFO to gas as soon as gas is available at the sites.

5. There is sufficient committed plant (GT, Thermal and diesels) that new plant is not needed until 2017 onwards (Base Forecast).

6. Additional (new) capacity after the committed short-term plan should come from conversion of simple cycle GTs to combined cycle (i.e. by the addition of waste heat boilers and a steam turbine). This increases the capacity of a plant by about 50% with no extra fuel burn. With conversion of GTs to CC, new CC plant is also selected from 2018, with new large GTs from 2024.

7. However, the conversion of all the MegaDeal and a few other GTs to combined cycle, although economic, shows progressively less advantage the more that are converted. It is recommended that ME, in its successive generation planning exercises using WASP, keeps the option open of only converting some GTs (particularly the larger units) and instead installing more new large CC plant.

8. Additional thermal (steam) plant is not least cost. It is understood that ME's latest planning is considering new thermal power stations at Khayrat, Al Anbar, Al Shimal, and Salah El Deen. The long term planning analyses described in this report have shown that building these plants is not the least cost solution provided that GT and CC plant can be built instead.

9. It is economic to add the committed additional 550 MW interconnection. However, from 2015/16 the interconnectors will only provide peaking power, and tariffs should be structured to reflect this i.e. a two part tariff covering capacity and energy separately.

10. Gas and HFO availability should be sufficient as long as fuel infrastructure development follows the MO's plans. Surplus HFO from 2016 onwards could be reduced by changed refinery product mix, particularly in new refineries.

11. If gas is delayed such that new plant 2015 to 2019 cannot be converted to gas, the penalty is about US$ 5 billion. This assumes GTs installed running on HFO instead of CC - installing thermal plant burning HFO instead of GTs on HFO would be more expensive.

5. SHORT TERM TRANSMISSION PLANNING

5.1 Introduction

The short term transmission plan covers the period 2009 to 2015, and the main objectives were to identify what is required to:

- strengthen the existing grid system to satisfy transmission requirements arising from growing load demands (both from suppressed load and natural load growth)
- connect future generating stations to the grid system, and
- connect isolated load to the grid system.

PB and the ME Master Plan Team built PSS/E models of the 400/132 kV transmission system for the years 2009 to 2015. The models incorporated ME's short-term plan for nearly 13 GW of new generation (GTs, Thermal and diesel plant) from 2010 to 2015 and associated transmission reinforcements. This enabled any supplementary network reinforcements to be identified, based on the Base Case load forecast, load flow and fault level studies, and using the Planning Standards recommended below.

5.2 Planning Standards

The transmission plan has been developed based on our recommendations for a Planning Standard, which are based on best international practices for transmission planning development. The current condition of the Iraq electricity system is such that many aspects of the planning standard cannot be met at present, but the object of the plan is to develop a system as quickly as possible that meets the Standard, which is summarised below.

5.2.1 Recommended Planning Standards

The system (132 kV or 400 kV) shall be planned such that for an Intact system (i.e. no system outage) there shall not be:

- Any transmission equipment (132 or 400 kV) loaded above its nominal rating;
- Any unacceptable voltage conditions;
- Any unacceptable fault level conditions.

The transmission system will normally operate at a target frequency of 50 Hz +/- 0.5% (i.e. 50.25 Hz to 49.75 Hz).

The system (132 kV or 400 kV) shall be planned such that there is:

- No plant overloading under single planned or unplanned outage of any one circuit at a time;
- No stability issue under single planned or unplanned outage of any one circuit at a time.

5.3 Existing Transmission System

5.3.1 Introduction

The existing Iraqi transmission network uses 400 kV and 132 kV, as shown in Figure 9, which also shows the locations of the Grid Supply Points (GSPs), Bulk Supply Points (BSPs) and the major load centres in the country. The 132 kV network is the local load distribution network within each Governorate, with a few 132 kV ties to neighbouring Governorates, whilst the 400 kV network is the national grid bulk power transfer highway between the Governorates and with neighbouring countries. The network comprises:

- 3723km of 400 kV, twin 490/65mm2 ACSR, single circuit construction overhead lines with thermal rating of 100MVA;
- twenty four 400/132 kV substations (GSPs);
- 13,746km of 132 kV overhead lines;
- 209 132/33/11kV substations which are used as Bulk Supply Points (BSPs) to distribute electricity in the Governorates.

5.3.2 Problems with the Existing System

The major problem with the existing system is the high fault levels on the 132kV system, particularly in Baghdad. 17% of the BSPs in Iraq have three phase fault levels higher than 30kA, and all these BSPs are located in Baghdad city.

The 132kV fault level problem is identified as an urgent problem which has to be solved as soon as possible. Five solutions are suggested:

- Split the existing 132kV network with open points;
- Adopt a re-configuration methodology on the existing 132kV network;
- Re-configure the 132kV network to nearly equally distribute the BSPs among the GSPs, as shown in Figure 10;
- Adopt a standardized approach and switchgear upgrade for the new 132kV network extensions;
- Check the possibility of upgrading some of the existing switchgear ratings.

5.4 Short Term Plan 2010-2015

5.4.1 ME Generation Plan

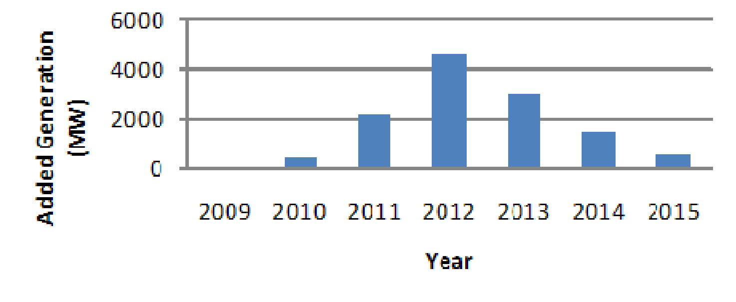
The ME generation plan involves almost 13 GW of gas turbine, thermal and diesel generation plants. Figure 11 shows the geographical distribution of the ME generation plan. Table 1 gives the yearly distribution of the generation as committed/planned by the ME. This plan shows that year 2012 is critical year with more than 4000MW expected to be connected to the network. This new generation will have a large impact on the transmission network.

5.4.2 Network

Load flow models were built using the power systems software PSSE for the years 2010 to 2015 based on the 2009 existing model, the ME generation locations and the ME initial single line diagrams of the generation connections to the transmission network. The generation plan and the BSP loads were then integrated into the network to obtain the comprehensive network models of the short-term plan, and load flow analyses were carried out on the year by year models.

Table 11 Generation Added Annually to the System

Year	MW Added to the Network
2009	7436 (Existing)
2010	445
2011	2238
2012	4598
2013	2976
2014	1492
2015	553



5.5 System Expansion Requirements

Table 12 gives the system reinforcement required from 2009 to 2015, and Table 13 gives the corresponding cost for the reinforcements of the transmission system and the cost to connect the ME committed generation to the transmission system.

5.6 Conclusions and Recommendations from Short-Term Transmission Planning

5.6.1 132 kV Network

1. The high fault levels on the existing 132kV system, particularly in Baghdad, have to be given immediate attention by:

    - splitting the 132 kV network at certain points to reduce the number of parallel feeds into any particular fault point;
    - embarking on an upgrade of any existing 132 kV switchgear which has low breaking capacity, particularly old switchgear and switchgear at or near to power plants.

2. It is recommended that the ME planning of the 132 kV system takes into account the three phase fault levels at the 132 kV busbars. For each Governorate the ME should avoid or minimise the number of 132 kV parallel paths to the 400 kV grid supply point. Also the 132 kV system should be split in such a way that the 400 kV grid supply points share the load based on how many grid supply transformers are in each GSP.

3. There are a few lines that exceed their thermal rating under N-1 contingency. These lines are of a rating less than 90MVA, and it is recommended that they either be reconductored with Teal or re-built with Teal or Double Teal.

4. It is estimated that the network will need about thirty seven BSPs in addition to the ME committed BSPs for year 2010 and 2011 to manage the Base forecast load growth.

5. Based on the 132kV conductor economic optimization analysis described in the Long Term Transmission report, it is recommended that the ME standardise their 132 kV overhead lines on Teal conductor and AAC.

5.6.2 400 kV Network

1. It is recommended that the ME add to their overhead line specifications a high capacity line (higher than the existing design twin ACSR of 1000MVA rating). Quad 490/65 conductor line is recommended (see the Long Term Planning recommendations in Section 6.8 - Items 7 and 8).

2. The load flow studies indicated the need to reinforce the 400 kV routes from Basrah to Baghdad along the eastern and western sides of the country. The studies showed that parts of these routes, particularly near Baghdad, require high capacity lines. The long-term studies show that future demand growth would require extensive reinforcements of these two routes, and hence it is recommended to start building these lines as early as possible. The long-term studies also point toward the need for building high capacity lines from Basrah towards Baghdad on the eastern side of the country, from the south to the west of Baghdad through the Middle Euphrates, and from Kirkuk towards Mosul. It is also recommended to build these lines as double circuits, stringing one circuit first and adding the second circuit in future if initial demand does not require both circuits initially.

3. By 2012 a third circuit has to be added to Qudus to be able to evacuate the extra generation. However, this connection can be to any point on the Baghdad ring, provided the 400kV fault level is satisfactory.

4. It is recommended that the 400 kV Baghdad ring be split at specific points to reduce fault levels on the 400 kV network in future. As an initial suggestion, the place of the split can be chosen in such a way as to isolate the Qudus and Sadr 400 kV generation from feeding into other 400 kV substations connected to the ring.

5. Figure 11 gives a geographical layout of the expected development of the 400 kV network in the short term.

Table 12 132 kV and 400 kV Reinforcement Requirements for 2009 to 2015

Item No.	Item Details	Unit Cost (Million USD)	2009		2010		2011		2012		2013		2014		2015		Total
			Number/ Length (km)	Cost (Million USD)	Number/ Length (km)	Cost (Million USD)	Number/ Length (km)	Cost (Million USD)	Number/ Length (km)	Cost (Million USD)	Number/ Length (km)	Cost (Million USD)	Number/ Length (km)	Cost (Million USD)	Number/ Length (km)	Cost (Million USD)	Number/ Length (km)
1	132kV Substation (AIS) - BSPs	17	0	0	11	187	17	289	23	391	4	68	3	51	7	119	65
2	400 SC quad 490/65 ACSR overhead lines	0.459	0	0	0	0	0	0	220	101	0	0	0	0	0	0	220
3	400 DC quad 490/65 ACSR overhead lines	0.774	0	0	0	0	0	0	0	0	0	0	0	0	230	178	230
4	400 SC twin 490/65 ACSR overhead lines	0.350	0	0	0	0	0	0	663	232	0	0	0	0	0	0	663
5	400 DC twin 490/65 ACSR overhead lines	0.525	0	0	0	0	0	0	46	24	0	0	0	0	0	0	46
6	132kV Overhead Line (Single Circuit) single Teal	0.220	136	30	120	26	839	185	690	152	120	26	90	20	210	46	2205
7	132kV Overhead Line (Single Circuit) twin Teal	0.289	68	20	0	0	26	8	690	199	120	35	90	26	210	61	1204
8	132kV Overhead (Double Circuit) single Teal	0.307	31	10	0	0	0	0	0	0	0	0	0	0	0	0	31
9	400/132/11kV ,250MVA Auto Transformer AIS Connected	2.91	1	3	1	3	1	3	1	3	4	12	1	3	2	6	11
10	132kV Cable, 800mm2 Al/XLPE (single circuit single cable)	2.5	33	83	18	45	1	3	70	175	0	0	30	75	20	50	172
Total cost for the Year (Million USD)			**144**		**261**		**487**		**1,277**		**141**		**175**		**460**		**2,945**

Note 1: These 400kV lines are the minimum requirements to satisfy the base case demand (option 1)

Note 2: The above costs do not include any GSP planned by the ME

Table 13 Overall Plan Costs

Item	Year							Total
	2009	2010	2011	2012	2013	2014	2015	
Cost of required reinforcements	144	261	487	1,277	141	175	460	2,945
Cost of generation connections (note 1)	0	0	69 (135)	553 (998)	300 (552)	97 (175)	8 (16)	1,027 (1,876)
Total Cost (Million USD)	**144**	**261**	**556 (622)**	**1830 (2275)**	**441 (693)**	**272 (350)**	**445 (453)**	**3,972 (4,821)**

Note 1 : These costs are assuming both generation connection substations (132kV and 400kV as given by the ME -Appendix 12) are AIS, figures in paranthesis are assuming both substations are GIS.

Figure 9 400 kV & 132 kV Existing Transmission Network – Load Centres and Transmission Directorates

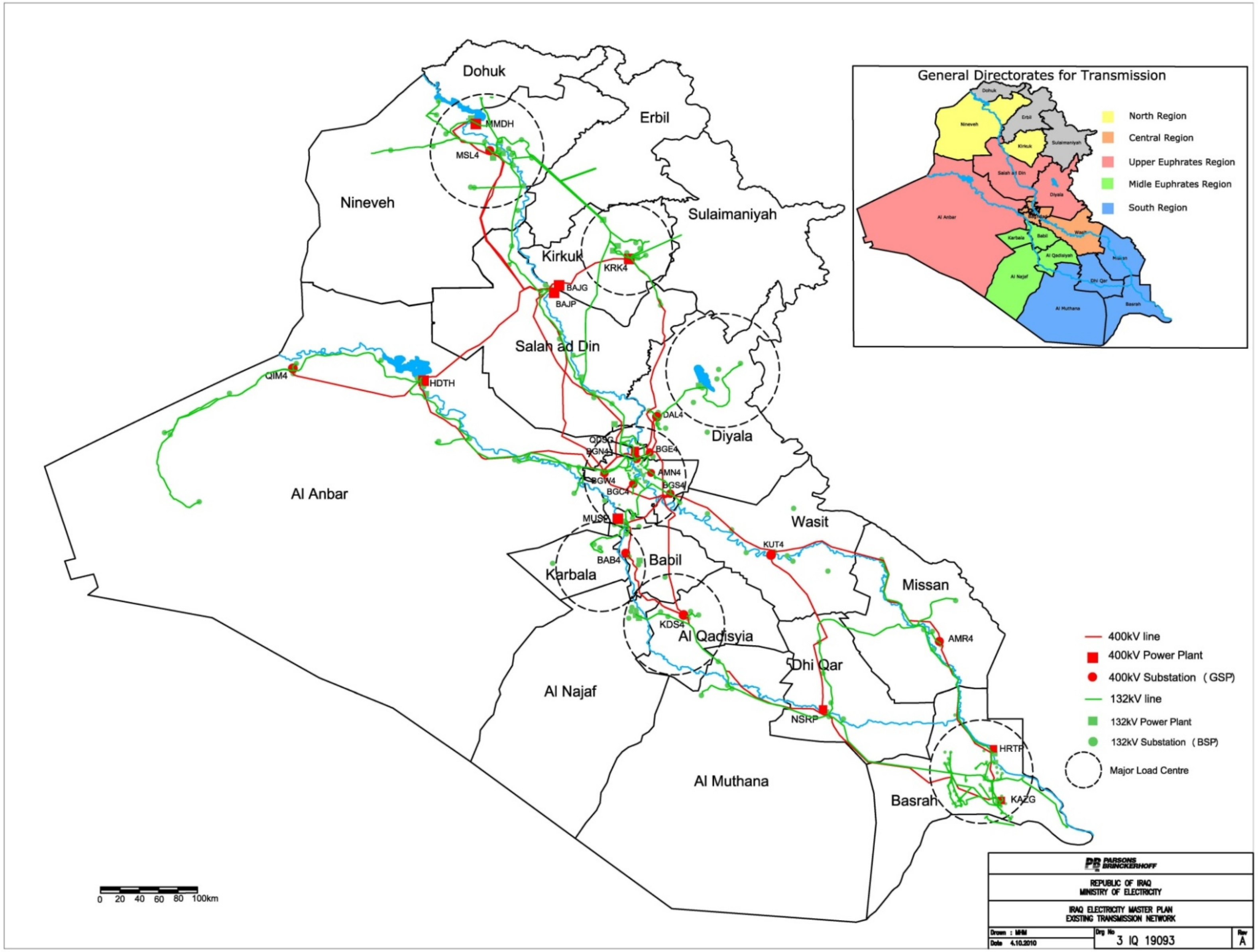


Figure 10 400 kV & 132 kV Network of Baghdad City – Required Re-Configuration

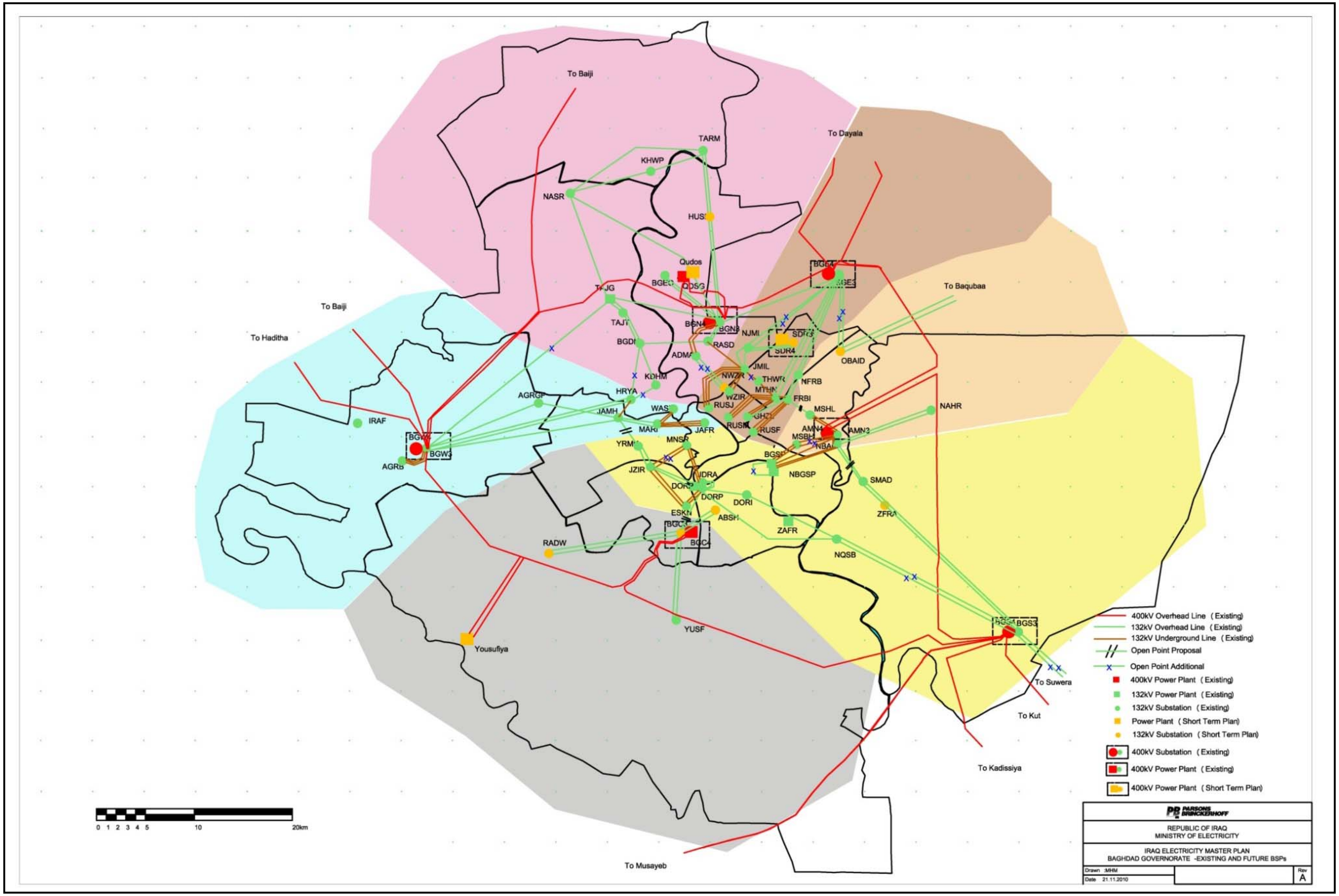
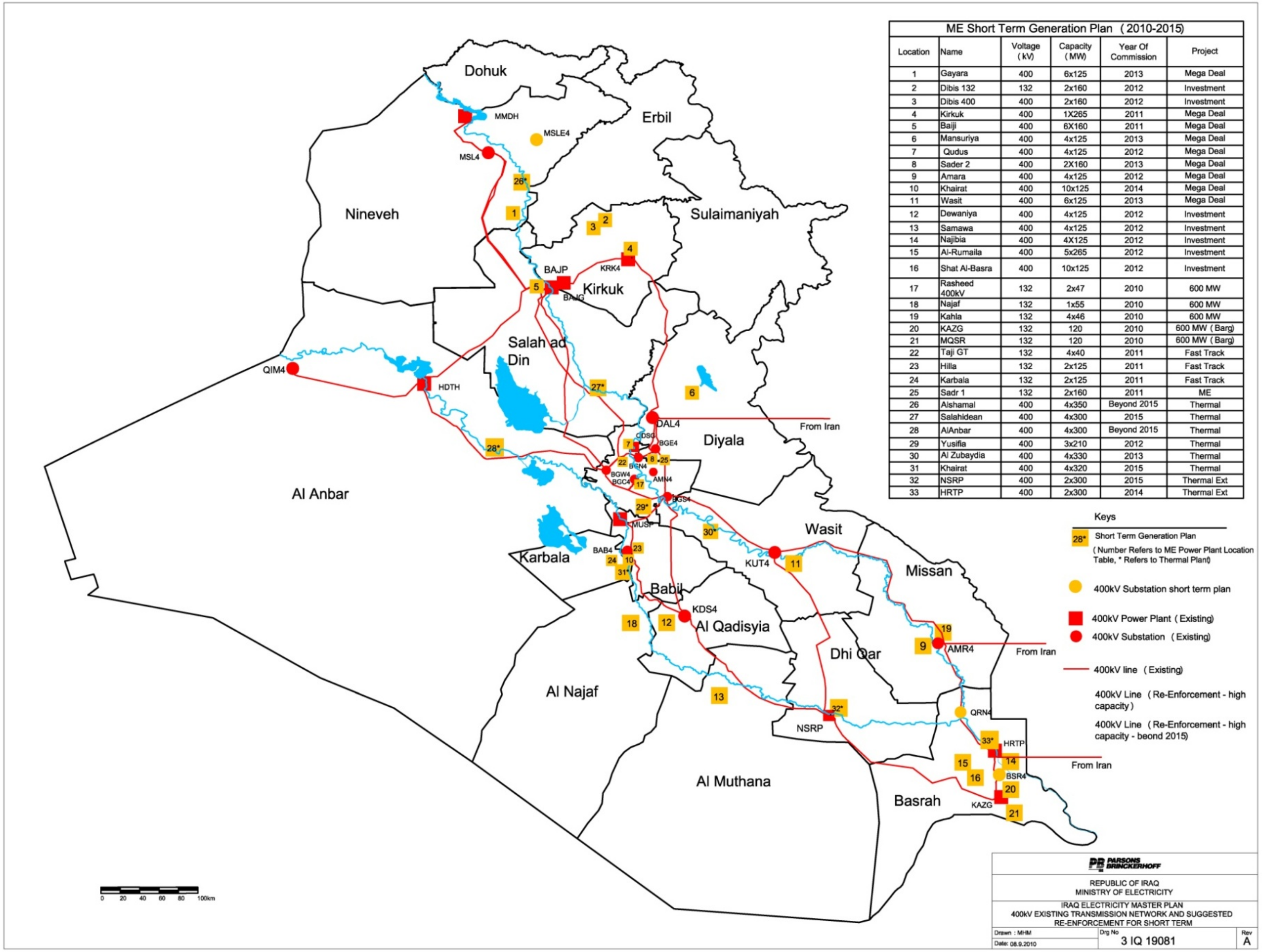


Figure 11 ME Committed Short-Term Plan



ME Short Term Generation Plan (2010-2015)

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

6. LONG TERM TRANSMISSION PLANNING

6.1 Introduction

The long-term transmission planning report deals with various aspects of developing a long-term strategy to expand the transmission network in Iraq for the period 2015-2030. Beyond 2015 Iraq's electrical transmission network developments will be influenced by two main factors:

- Power demand magnitude and distribution;
- Generation fuel availability and location.

The generation planning studies concluded that the most economical fuel to use to generate electricity in Iraq is gas. MO information indicates that about 60% of future gas resources will come from the Southern region (Basrah/Missan/ThiQar), followed by Diala and Al-Anbar with 20% and 10% respectively.

Consideration of the above information points to the following critical questions:

- Should generation be built in the Southern region and the power be transmitted to Baghdad by overhead lines? - Scenario A - or
- Should Baghdad demand be satisfied by building generation around Baghdad and transferring gas from the south by pipelines? - Scenario B.

In addition to answering the above strategic question, the long term plan also estimates the transmission network expansion requirement up to 2030.

6.2 Methodology

The methodology followed in developing the long term transmission plan consists of the following:

- Develop a model to evaluate power transfer between generation and demand centres for the entire country.
- Develop load flow models to evaluate the transmission network development.
- Estimate the network expansion requirements.
- Review design aspects of major network components.
- The inputs to the above processes are:
    - The load (demand) forecast
    - The ME short term committed generation plan
    - The long term generation plan

- o The transmission short-term plan
- o The ME/MO fuel expectation and the MO committed/planned fuel transportation infrastructure.

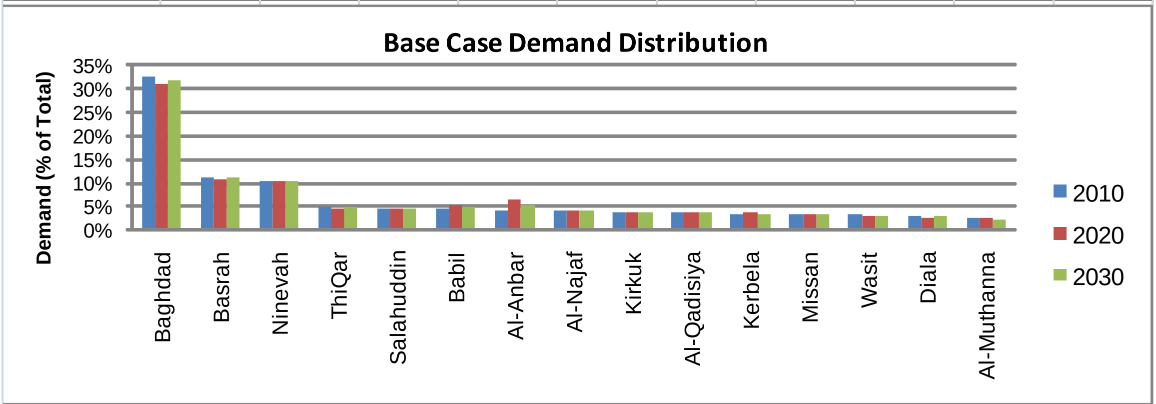
New generation plant in a particular area is aggregated in the long-term load flows. However, this does not mean that all the generation is connected at one point.

6.3 Demand and Generation Distribution

Iraq demand is distributed among the Governorates as shown in Table 14, which shows that Baghdad has the maximum demand, at about 35% of the total.

Table 14 Demand Forecast

Governorate	2010		2015		2020		2025		2030	
	Base	**High**	**Base**	**High**	**Base**	**High**	**Base**	**High**	**Base**	**High**
Baghdad	3822	3874	4982	5434	6156	7475	7678	10319	10058	14410
Basrah	1317	1335	1738	1896	2154	2618	2723	3664	3567	5115
Ninevah	1246	1262	1664	1810	2019	2438	2520	3366	3311	4719
ThiQar	577	585	730	798	930	1135	1179	1594	1536	2211
Salahuddin	552	560	713	779	885	1077	1121	1512	1458	2095
Babil	541	548	856	919	1017	1201	1237	1608	1578	2193
Al-Anbar	509	516	1136	1192	1268	1429	1457	1780	1751	2285
Al-Najaf	500	507	661	721	823	1000	1029	1385	1345	1930
Kirkuk	459	465	584	639	740	903	936	1265	1208	1739
Al-Qadisiya	437	443	576	627	716	866	891	1191	1153	1645
Kerbela	398	403	601	647	730	863	885	1152	1122	1561
Missan	390	395	514	560	651	788	815	1091	1052	1501
Wasit	387	392	520	563	614	734	738	972	934	1312
Diala	354	359	445	487	549	670	691	935	910	1312
Al-Muthanna	292	296	389	423	479	578	589	784	740	1050
TOTAL	**11781**	**11939**	**16111**	**17494**	**19731**	**23775**	**24489**	**32619**	**31722**	**45078**

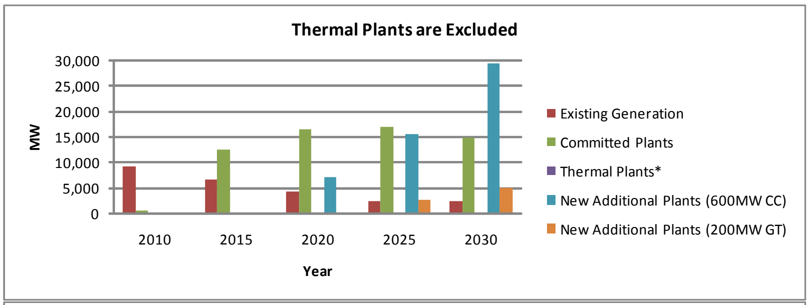


The generation growth is shown in Table 15. Baghdad and Basrah are the major centres for generation up to 2020, but beyond that the picture would change if the gas resources are developed as per the MO plan. In that case the major centre of generation would be in the south of the country. Two options are shown – one without ME's additional four thermal plants included, and one including them. However, since the generation planning has shown that installing the four additional plant is not a least cost solution, the economic comparison between the scenarios has been based on the cases without the additional thermal plant, although the conclusions will be similar if the additional plant were installed.

Table 15 Generation Plan (High Load Forecast)

Thermal Plants are Excluded

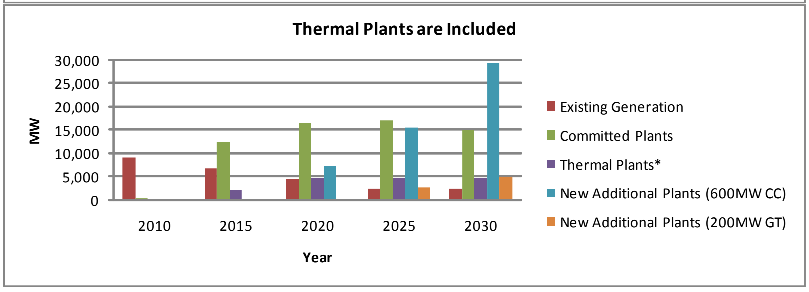
Generation	Year				
	2010	2015	2020	2025	2030
Existing Generation	9198	6767	4405	2483	2483
Committed Plants	464	12520	16540	16933	14934
Thermal Plants*	0	0	0	0	0
New Additional Plants (600MW CC)	0	0	7200	15600	29400
New Additional Plants (200MW GT)	0	0	0	2600	5000
Total	9662	19287	28144	37616	51817



Thermal Plants are Included

Generation	Year				
	2010	2015	2020	2025	2030
Existing Generation	9198	6767	4405	2483	2483
Committed Plants	464	12520	16540	16933	14934
Thermal Plants*	0	2282	4674	4674	4674
New Additional Plants (600MW CC)	0	0	7200	15600	29400
New Additional Plants (200MW GT)	0	0	0	2600	5000
Total	9662	21569	32818	42290	56491

Notes :
* Al Shimal, Kaiyrat, Al-Anbar and Salahudin (derating factor of 0.92 is applied)



6.4 Gas Resources and Pipelines

Table 16 summarizes the MO’s gas resource forecast and Figure 12 shows MO’s gas pipe lines development plan.

The following is a summary of the MO’s gas pipelines plan:

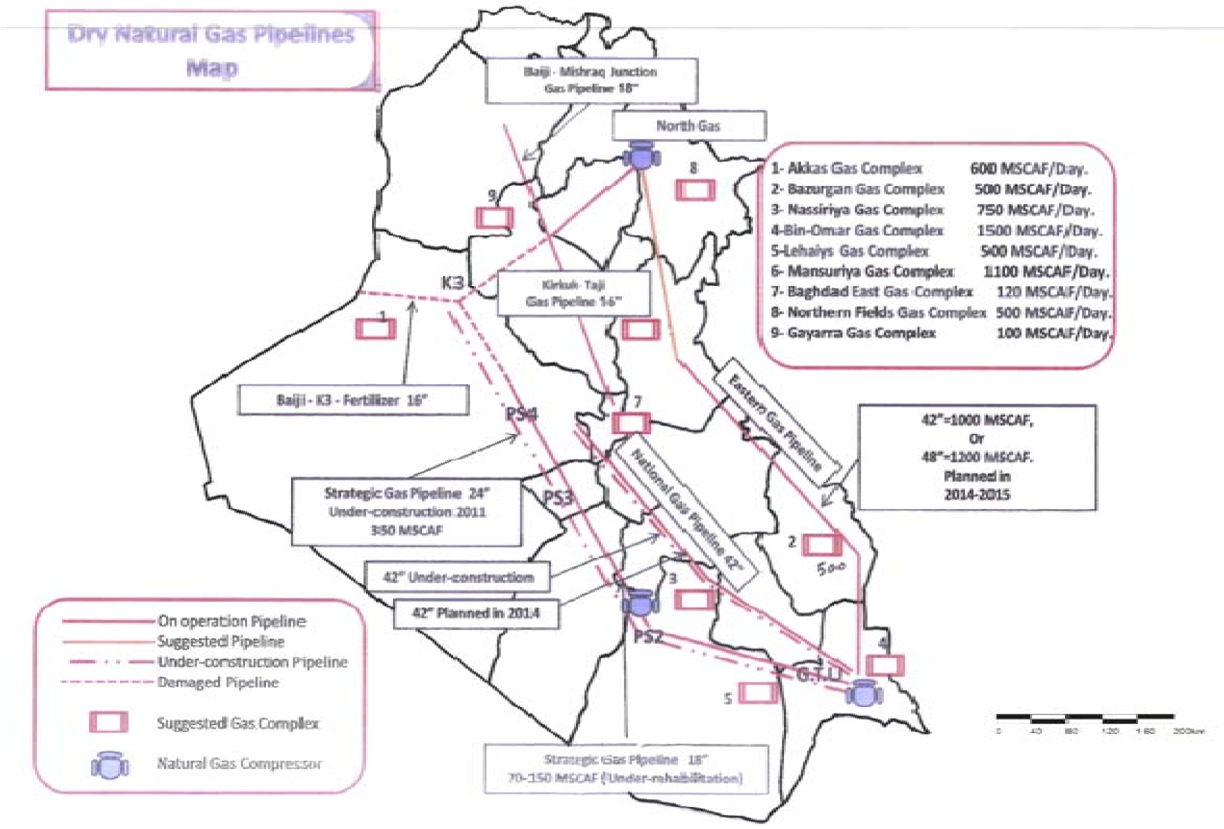
- Under Construction Gas Pipeline: 42” diameter, Basrah-Thiqar-Muthana-Qadisiya-Babil-Baghdad;
- Strategic Gas Pipeline: 24” diameter, under construction expected to finish by 2011, Basrah-Muthan-Najaf-Kerbala-Al-Anbar;
- Eastern Gas Pipeline: 42” diameter planned for 2014/2015 – Basrah-Misan-Wasit-Diyala;
- National Gas Pipeline: 42” diameter planned for 2014 –Basrah-Thiqar-Muthana-Qadisiya-Babil-Baghdad;
- Other gas pipelines:
  - o 16” Diameter: Kirkuk – Baiji - Taji (North Baghdad)
  - o 18” Diameter: Baiji – Mishraq (Ninevah).

Table 16 Availability beyond 2015 as Predicted by MO

Location No.	Gas gathering Complex Name	Millions SCF/Day	% of Total	Location	
				Governorate	Region
1	Akkas	600	11	Al-Anbar	Western
2	Bazyrgan	500	9	Missan	Sothern
3	Nassiriya	750	13	ThiQar	
4	Bin-Omar	1500	26	Basrah	
5	Lehaiys	500	9	Basrah	
6	Mansuriya	1100	19	Diala	North East
7	Baghdad East	120	2	Baghdad	
8	Nortehern Fields	500	9	Kirkuk	Northern
9	Gayarra	100	2	Ninevah	
Total		5670			

Regional locations are with respect to Baghdad

Figure 12 MO Gas and Gas Pipe Lines (Committed/Planned)



6.5 Power or Gas Transfer Comparison

The entire country has been divided into six areas based on the geography of the demand shown in Figure 13. The transfers of power or gas between these areas have been evaluated in an Excel model and used to determine the EHV lines or gas pipelines required. Three scenarios were developed:

Scenario A
In this scenario it is assumed that electrical power (MW) is generated where the gas resources are located and transmitted to major demand centres by HV transmission lines.

Scenario B
In this scenario it is assumed that gas is transferred by pipelines to where the major demand centres are, and power stations are built near the demand centres, such that demand and generation balance in each area.

Scenario C
This scenario assumes that part of the MO pipelines infrastructure plan will be achieved by MO, and hence there will be no need after 2020 to build all the overhead lines required by Scenario A or all the pipelines required by Scenario B. This case is considered as a midway scenario between Scenario A and Scenario B.

A through-life discounted cost model was developed to compare Scenarios A and B on the basis of the present value of all the investment and annual costs. The latter comprised operation and maintenance, plus the cost of electricity losses in Scenario A and the cost of power and energy for compression in Scenario B.

Table 17 Present Value of Electricity and Gas Scenario Costs

Scenario	PV US$ million
A	2790
B	2210

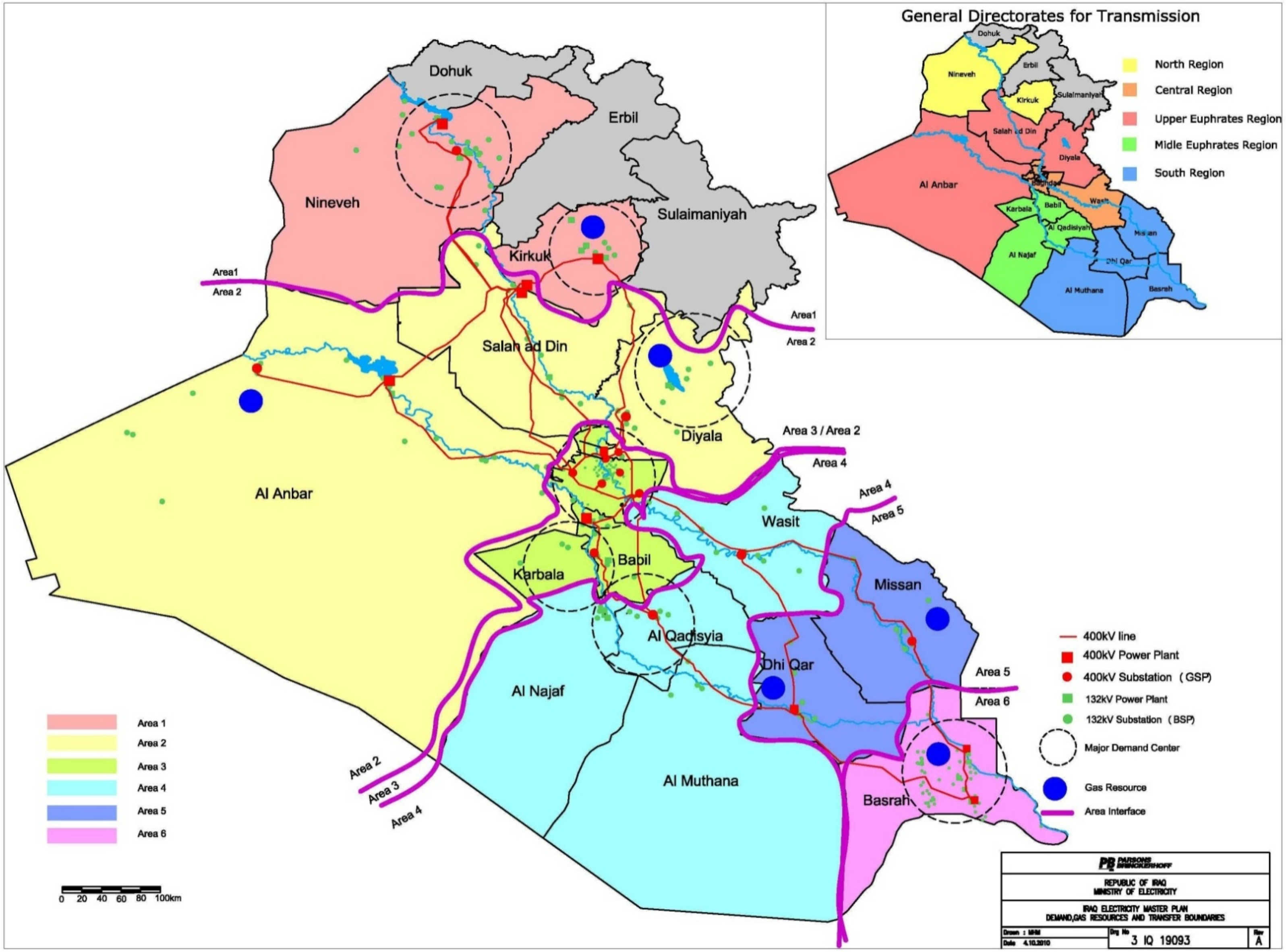
The results show that the gas transfer option is about 20% cheaper than the 400 kV transmission option.

However, the mixed solution of Scenario C will provide greater supply security, and lessen the effect of delays in gas pipeline development (which may be outside of ME’s control) or of electricity development. It is therefore recommended that Scenario C should be the scenario that is followed. The MO has development plans for the gas infrastructure and close liaison is recommended so that the transfers required by the ME are incorporated in their planning.

6.6 Power System Analysis and Network Design

Load flow, fault level and dynamic stability studies have been carried out up to 2030 for the High load forecast for Scenarios A and C. The High load forecast case has been used because the long life of transmission plant makes it important to take a long term view so as to avoid possible stranded assets. Conductor and transmission voltage optimisations, and network design aspects have also been examined in the Long-Term Transmission Planning report, together with an overview of transmission protection. The results of this work feed into the estimate of transmission requirements and costs, and to the conclusions and recommendations given in Section 6.8.

Figure 13 Model for Power/Gas Transfer



6.7 Required Reinforcements and Costs

Table 18 to Table 23 give the long term reinforcement requirements and associated costs for 2011-2015, 2016 – 2020, 2021 – 2025 and 2026 – 2030, as well as the totals for 2011 – 2030. The number of BSPs is based on ME's current design, which utilises 3x63 MVA 132/33/11 kV transformers, giving a firm capacity of 2x63 MVA, i.e. 126 MVA. The GSP design is based on two, three or four 250 MVA 400/132kV auto-transformers. Overall, it is estimated that the ME will have to invest an average of US$ 430 million per year in the transmission network to be able to satisfy the Base load forecast for the recommended Scenario C development.

The estimates do not include the cost of generation connections.

Table 18 132 kV Substation (BSP) Requirements and Costs

Forecast Case		Year				Total
		2015	2020	2025	2030	
Base	Number of New BSPs	38	32	42	63	**175**
	Cost (MUSD)	**646**	**544**	**714**	**1,071**	**2,975**
High	Number of New BSPs	48	54	81	109	**292**
	Cost (MUSD)	**816**	**918**	**1,377**	**1,853**	**4,964**

Table 19 132 kV Overhead Line Requirements and Costs

Forecast Case		Year				Total
		2015	2020	2025	2030	
Base	Demand (MW)	16111	19731	24489	31722	
	New Lengths (km)	2280	1920	2520	3780	**10,500**
	Cost (MUSD)	**601**	**506**	**664**	**996**	**2,767**
High	Demand (MW)	17494	23775	32619	45078	
	New Lengths (km)	2880	3240	4860	6540	**17,520**
	Cost (MUSD)	**759**	**854**	**1,281**	**1,723**	**4,617**

Note: It is assumed here that 50% of the 132kV new overhead lines are of SC Teal and the other 50% are DC Teal

Table 20 400 kV Substation (GSPs) Requirements and Costs

Base Case

Item	2015		2020		2025		2030		Total	
	Number	Cost	Number	Cost	Number	Cost	Number	Cost	Number	Cost
AutoTx on existing GSP	9	26	1	3	1	3	6	17	**17**	**49**
1x2 GSP	4	148	2	74	4	148	3	111	**13**	**481**
1x3 GSP	1	49	0	0	0	0	1	49	**2**	**98**
1x4 GSP	5	300	0	0	0	0	1	60	**6**	**360**
Total Cost (MUSD)		523		77		151		237		**988**

High Case

Item	2015		2020		2025		2030		Total	
	Number	Cost	Number	Cost	Number	Cost	Number	Cost	Number	Cost
AutoTx on existing GSP	9	26	3	9	5	15	13	38	**30**	**87**
1x2 GSP	5	185	5	185	2	74	5	185	**17**	**629**
1x3 GSP	1	49	0	0	1	49	2	98	**4**	**196**
1x4 GSP	5	300	0	0	2	120	3	180	**10**	**600**
Total Cost (MUSD)		560		194		258		501		**1,512**

Table 21 400 kV Overhead Line Requirements

	2015			2020			2025			2030			Total (km)		
	A-1	A-2	C-1	A-1	A-1	C-2	A-1	A-1	C-3	A-1	A-1	C-4	A-1	A-2	C-1
DC Quad	971	746	879	170	284	270	540	940	100	620	0	250	2301	1970	1499
SC Quad	371	516	441	40	180	60	411	760	261	114	299	180	936	1755	942
DC Twin	110	110	72	0	0	0	0	0	120	0	0	0	110	110	192
SC Twin	245	190	240	0	70	55	155	65	130	80	0	115	480	325	540

A-1 : Scenario A with thermals

A-2 : Scenario A without thermals

C-1 : Scenario C with thermals

Table 22 400 kV Overhead Line Costs – High Load Forecast

	2015	2020	2025	2030	Total
	Cost (MUSD)				
Scenario A (with thermals)	1,083	153	688	568	2,491
Scenario A (without thermals)	965	339	1,150	157	2,611
Scenario C (with thermals)	1,029	260	315	328	1,932

Table 23 Overall Transmission Costs

	2015	2020	2025	2030	Total MUSD)
Base Demand + Scenario A (with thermals)	2,853	1,279	2,217	2,872	9,222
Base Demand + Scenario A (without thermals)	2,735	1,466	2,678	2,461	9,341
Base Demand + Scenario C (with thermals)	2,799	1,387	1,844	2,633	8,662
High Demand + Scenario A (with thermals)	3,218	2,118	3,603	4,645	13,584
High Demand + Scenario A (without thermals)	3,101	2,304	4,065	4,234	13,704
High Demand + Scenario C (with thermals)	3,164	2,225	3,230	4,405	13,025

MUSD : Million US Dollar

6.8 Conclusions and Recommendations from Long-Term Transmission Planning

1 The existing network exhibits short circuit level problems at the 132 kV level. This requires re-configuration of the 132kV network around Baghdad. New 132 kV network extensions should follow the configurations recommended in Volume 4.

2 It is recommended that the ME reduces their list of 132 kV conductors for new circuits to only two sizes; Teal and AAC.

3 It is recommended that ME continue with their standard BSP design, which utilises 3x63 MVA 132/33/11 kV transformers. However, better utilisation of the 33 kV and 11 kV windings is recommended by properly distributing the load on the two windings according to their ratings. Consideration could, however, be given to specifying forced air cooling be fitted for use under outage conditions (ONAF), which could increase the transformer ratings to 80 MVA.

4 A through-life economic analysis shows that it is cheaper to transfer gas from sources to load centres by pipelines than to produce power at gas sources and transfer bulk power to load centres by EHV lines. However, taking into account the need for supply security and timely execution, it is recommended that Iraq follows an intermediate path whereby some bulk energy is transferred as gas and some by developing the EHV transmission system – Scenario C in this report. The MO has development plans for the gas infrastructure and close liaison is recommended so that the transfers required by the ME are incorporated in their planning.

5 The EHV transmission system voltage should continue to be 400 kV. Use of 765 kV is a more expensive option in through-life economic terms, and is not recommended at this stage.

6 It is recommended that ME start planning for the construction of new 400 kV lines as soon as possible in order to catch up with generation development.

7 For the high level of demand and generation expected, the ME is recommended to upgrade their 400kV line specification for new circuits from twin to quad conductor transmission lines. The existing 400kV design based on twin 490/65 ACSR does not have sufficient capacity to handle the future high flow of power on the network.

8 The analysis in this report shows that the highest expected flow on the 400kV network and under N-1 contingency is around 2500MVA. This is approximately equal to the thermal rating of quad 490/65 ACSR. The 490/65 conductor in a quad formation is also shown to be an economical option for the long term. Another advantage of quad 490/65 is that this type of line is based on a conductor which is already a standard ME conductor on the existing twin conductor 400kV lines. Hence this type of new line is recommended.

9 The new 400 kV lines should be built as double circuits, stringing one side first if needed. This will save the ME cost and time.

10 As a consequence of adopting a new 400kV line design with higher rating, it is also recommended that the ME upgrade their 400kV switchgear thermal and short circuit ratings. The existing 400 kV switchgear is rated for 2000 amp and suggested 400 kV switchgear candidates are 3000 amp and 3500 amp. For the short circuit rating it is recommended to upgrade to the level of 50kA or higher.

11 It is recommended to update the PSS/E transmission system models (load flow, fault level and dynamic stability) and revise the analysis on a yearly basis.

12 It is recommended that the ME uses the load flow models to analyse the re-configuration and re-structuring of the local 400kV network around Baghdad to accommodate the new 400kV lines and the expected increase in the 400kV fault levels.

13 It is also recommended that the load flow models be used to develop the local 400kV networks which, in the Masterplan studies, have lumped generation assumed for the future gas sources.

14 The protection operation times plus switchgear opening times on the ME 400 kV network are lower than the 400 kV critical clearance times determined by transient stability studies, and are therefore satisfactory. The transient stability studies also indicate that the network is stable under credible contingency events of tripping a highly loaded circuit from a network branch, generation units or bulk load.

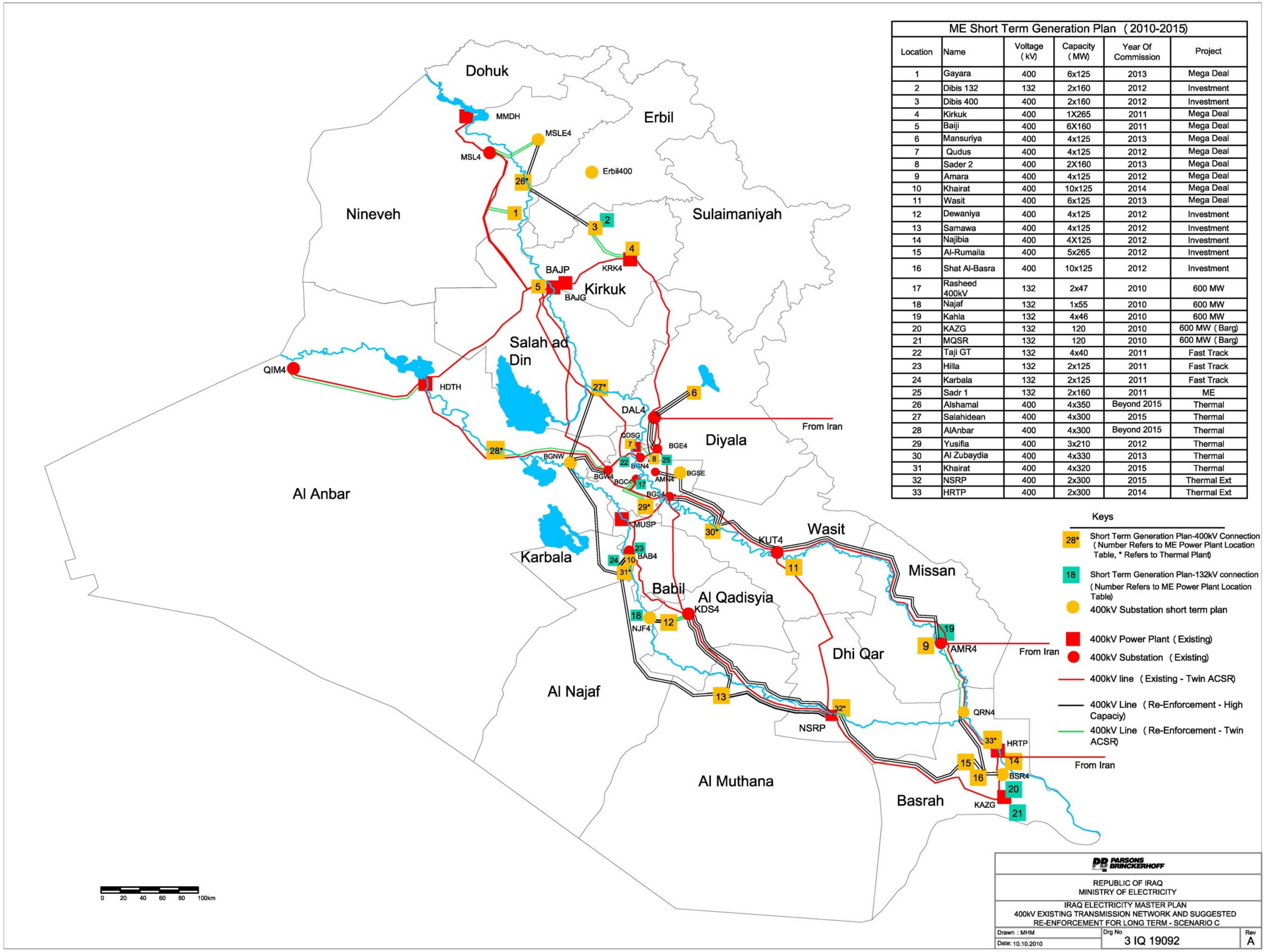
15 The ME should produce comprehensive protection application and setting policy documents. A protection maintenance policy should also be produced.

16 Fault records should be kept for all fault incidents and all protection operations (including failure to trip), and these statistics should be analysed periodically.

17 An up-to-date record should be kept of as-installed protection settings and protection scheme details. A dedicated team(s) should be appointed to create the ASPEN database/s and continually update it. Updates should be carried out at regular intervals of at least every month

18 Training has been given to the ME’s Planning and Studies office as part of the Masterplan activities. It is recommended that a follow-on training programme for the engineers and specialists of the Planning and Studies office should be developed.

Figure 14 Expected Future Development of the 400kV System



ME Short Term Generation Plan (2010-2015)

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

7. DISTRIBUTION PLANNING

7.1 Introduction

Iraq possessed in the past a relatively robust electricity system. However, many years of sanctions, conflict, and lack of investment have resulted in a system struggling to keep up with a rapidly rising demand. In general the distribution system has suffered substantially from lack of investment, both in the network itself and in the planning and maintenance staff. The construction and maintenance of the distribution system has a considerable impact on the quality of supply to consumers and the efficiency of the network. The distribution section of the ME is typically having to react to short-term problems rather than being able to develop medium and long-term plans and strategies.

Due to a restricted supply situation, load shedding is widespread. Because of this unreliable supply most consumers have resorted to connecting to a private supply of electricity. Private generation is particularly pervasive at low voltage (LV) and is used in both rural and urban environments.

Due to the uncontrolled and unplanned expansion of the LV networks, much of the distribution network is overloaded. As a result of insufficient energy metering and a subsidised tariff, there are no satisfactory measures in place to be able to control this consumption.

7.2 Capacity Development

The primary aim of the distribution portion of the Iraq Masterplan has been to develop the ME's capability to conduct distribution planning. With close cooperation from the ME, PB has designed and delivered documents, equipment, software tools and training. The capacity development programme involved distribution staff from the Planning and Studies Department and from all seven directorates. It was a mixture of classroom instruction, interactive workshops, and practical hands-on training with distribution planning software tools. Over the project duration, almost three months of training was given to the distribution planning team.

A distribution planning laboratory has been supplied in the ME headquarters in Baghdad, using CYMDIST, a popular distribution planning software package, and is designed to be expandable. Additionally, stand-alone CYMDIST workstations have been provided for use in each of the seven Distribution Directorates.

To give practical experience with the tools used to develop distribution plans, the ME selected a 132/33/11 kV Bulk Supply Point from each of the Directorates. The ME Masterplan distribution planning team collected data regarding the network supplied by each BSP and built electrical models in CYMDIST simulating the current performance of the MV and LV networks.

Although the main use of the models has been as a training tool, they will allow the ME to start to develop plans to rehabilitate and reinforce the distribution network, in order to bring them up to the desired standard. By involving staff from each of the Directorates in the training, they can replicate the methodology in their local areas and pass knowledge onto others.

7.3 Background

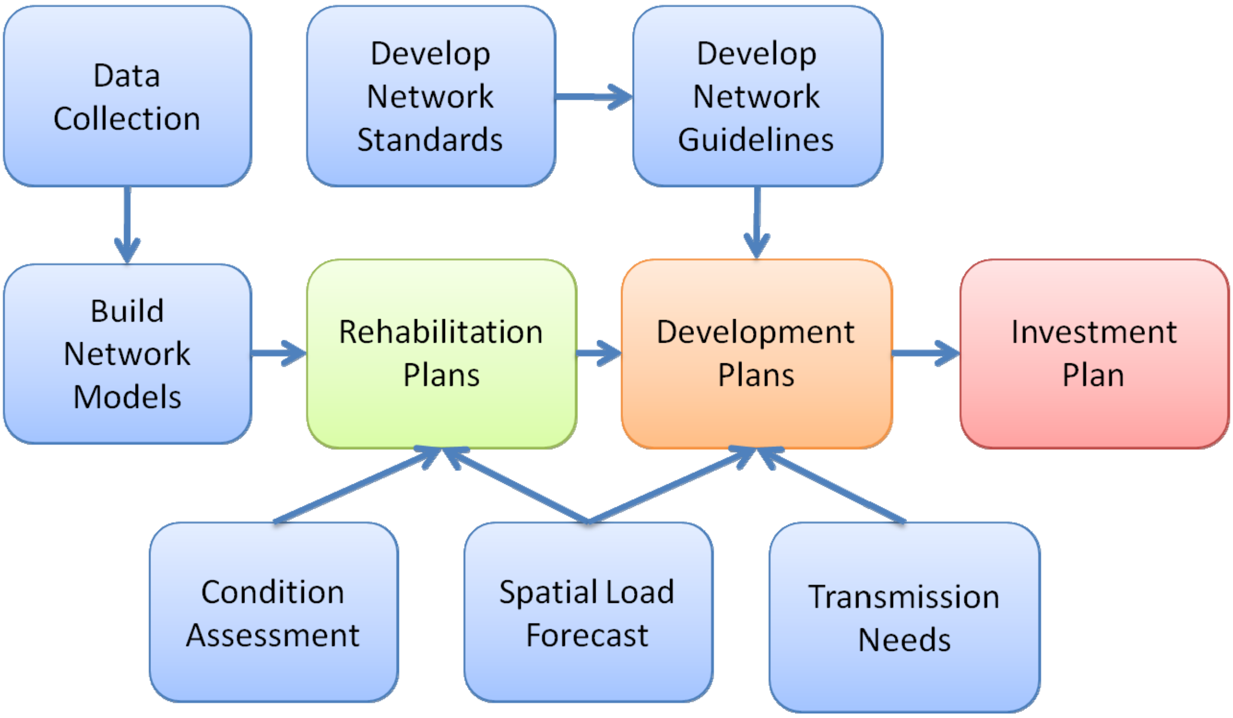
PB undertook a sample based condition assessment of the distribution network. With the majority of the Iraq network in a poor state, maintenance generally appears to suffer from a lack of spare parts, and there is a large variance of maintenance practices. This lack of spare parts and correct maintenance procedures are putting the integrity of the existing network at risk.

7.4 Methodology

Distribution planning is a complex, resource intensive process which requires good local knowledge of condition, loads, and future growth. Whilst complete detailed plans for all of Iraq are outside of the scope of the Masterplan, the focus of the capacity development programme was to begin equipping the ME Distribution Department with the tools and knowledge required to be able to conduct the planning that is necessary.

The general methodology followed by the ME Distribution Planning team is shown in Figure 15.

Figure 15 General Methodology



7.5 Planning Standards and Guidelines

Planning standards are based on the desired requirements for the distribution system and the quality level. They set standards which the network must meet that balance reliability, cost, and quality. Planning guidelines are documents created by a utility to help guide network development by distribution planners against these standards.

PB have developed a number of standards for use by the ME as well as guidelines for the development of the network, and these have been included in Volume 5.

7.6 Network Modelling

To build a network model of the distribution system requires substantial data regarding the network and its assets.

The format of this information varied from Directorate to Directorate and, given the general condition of the network, some of the data was considered out-of-date. However, by concentrating on a particular area of their networks the ME Distribution Masterplan team was able to source reasonably accurate information about the majority of the 33 and 11 kV feeders. This data was still in paper-based formats and so required a substantial amount of manual input and drawing by the ME team. In spite of this, the work completed by the ME distribution planning team as part of the Masterplan was exceptional, particularly given the effort required and the timeframe.

7.7 Estimated Investment Costs

The estimated distribution investment requirements are given in the tables below. These costs cover all development downstream from the BSPs and include 33 kV, 11 kV and LV. The quantity of equipment per BSP has been based on typical quantities in Iraq. The rehabilitation cost has been based on the sample condition assessments carried out.

Table 24 Estimated Distribution Investment 2011 - 2015

Distribution Rehabilitation		
No of existing BSPs		209
Cost per BSP	US$ million	40.9
Total Cost	US$ million	8,548
Cost per year	**US$ million**	**1,710**
Distribution from New BSPs		
No of new BSPs		38
Cost per BSP	US$ million	122.2
Total Cost	US$ million	4,644
Cost per year	**US$ million**	**929**
Total Cost	**US$ million**	**13,192**
Total Cost per year	**US$ million**	**2,638**

Table 25 Estimated Distribution Investment 2016 – 2030

Period	No of New BSPs	Cost per BSP US$ million	Cost in period US$ million	Cost per year US$ million
2016 - 2020	32	122.2	3,910	782
2021 - 2025	42	122.2	5,132	1,026
2026 - 2030	63	122.2	7,699	1,540
2016 - 2030	137	122.2	16,741	1,116

The total investment required from 2011 to 2030 is estimated as US$ million 3,754. The average investment per year from 2011 to 2016 is much higher than later years due to the rehabilitation cost.

7.8 Main Recommendations from Distribution Planning

7.8.1 Capacity Development

The training that was delivered to the ME needs to be maintained and developed further. Some recommendations for this area are:

- Periodic training in planning software such as CYMDIST to teach new users and refresh existing users
- Expansion of the existing usage of CYMDIST and other distribution planning tools and techniques
- Development of an internal training programme (including handouts and notes) in English and Arabic.
- Cross-department training and formalised interaction e.g. between Operations and Maintenance and the Planning departments, and between Transmission and Distribution departments, etc.
- Provide access to expertise and support from international consultants and key equipment suppliers.
- The ME planners need to gain further knowledge and experience of modern distribution system technology and practices. It is suggested that there is more active participation by the ME in the wider distribution industry both within the Middle East and further afield.

7.8.2 Loss Reduction

As previously mentioned, the condition of the distribution network is poor, which has an impact on the quality and efficiency of supply. The power and energy losses within a system are the input less the output. They are inherent in any electrical network and can be viewed as the ‘cost’ of delivering electricity. However, like any other business cost, losses must be managed to the appropriate economic level, which is where the cost of further reducing losses balances the further investment needed to reduce them i.e. marginal costs are balanced.

Metering is not consistent across Iraq, making it difficult to measure what the loss levels are. However the condition of the network means that the Iraq network has quite high levels of losses, and thus requires immediate action.

It is therefore highly recommended that the ME begin the implementation of a Loss Reduction Programme immediately. Loss Reduction Programmes are generally self-financing even over a relatively short period of time. The reduction in technical losses plus the associated improvement in voltage quality to the consumer means that there are savings in both energy and capacity costs. In addition, a reduction in non-technical losses will increase ME’s income, and can also lead to a reduction in consumption.

Arguably the most cost effective way to reduce losses at the distribution level is to ensure that maintenance and construction problems are corrected. As the ME already employs staff to undertake this work, the additional costs should be minimal. Additionally PB has proposed a number of network standards for the ME to use on their system. If these standards are followed, then losses can be generally kept within acceptable ranges. This means keeping:

- voltage within the required range;
- equipment loaded to standard levels; and
- power factor at optimal levels.

7.8.3 Planning Standards and Guidelines

The planning standards and guidelines provided by PB will only become beneficial if they are used throughout the entire distribution network. Procedures and regular training should be implemented to ensure that they are widely understood and used. Additionally, feedback and suggestions for document revision from all the Directorates should be used to update the standards and guidelines as necessary.

To encourage wider usage, the ME may need to develop parallel documents in Arabic, although care will need to be taken to ensure that these match the intent of the English versions.

7.8.4 Planning Information

There are substantial differences within the ME as to how and what information is recorded. It is important to standardise the data and records kept by the ME on their system, both between departments and between regions. These records should be in a consistent and coherent electronic format, and the important data should be accessible in a centralised repository.

The lack of accurate loading information at the primary substation level is also a significant issue. It needs to be redressed if the ME wishes their distribution planners to be able to make correct and cost effective decisions. Much of the data is collected by hand at present, and not always at the time of system peak.

Additionally this load is generally only recorded in amperes, with little information on the system voltage and power factor. Whilst not crucial to the planning process, the assumptions that planners are forced to make mean that they have limited knowledge of the true load on their network.

7.8.5 Condition Assessment

The representative condition assessment sample that PB completed allowed a reasonably accurate picture of the state of the Iraq distribution network to be developed. This allowed budgets for investment to be broadly estimated.

However the condition assessment is not sufficient for developing detailed rehabilitation or replacement plans for individual feeders and secondary distribution networks.

It is highly recommended that the ME conduct a complete inventory and condition assessment of the distribution network. As well as the condition of the equipment, this should also record the age and characteristics of the network assets. This would form the start of an ongoing condition monitoring programme to provide prioritised maintenance cues for the distribution department.

7.8.6 Meter Installation Programme

Meters provide important information for reconciling the usage of energy throughout the network and provide the ME with a way to recover costs proportional to individual consumer usage.

Un-metered usage also tends to be excessive when compared to metered usage, although this does depend significantly upon the set level of tariff. However it is expected that a meter installation programme (along with the required systems/procedures for meter reading and customer billing) would encourage more energy conservation amongst domestic consumers.

It is recommended that the ME consider implementation of a meter installation programme as soon as feasible. It will be important that this involves the development of the ‘back-office’ functionality in staff and software that will allow meter readings to be taken, recorded, and audited and energy usage calculated, billed, and recovered.

Inexpensive electronic meters that are robust and relatively tamper-resistant would provide advantages over the mechanical meters that are currently in use. Meter reading can be partially automated in order to reduce human error.

More advanced metering may need to be considered for large or industrial consumers to allow monitoring of power factor and reactive power consumption.

It is suggested that any implementation of ‘smart metering’ for domestic consumers be firstly evaluated under a pilot scheme to ensure cost effectiveness and demonstrate tangible benefits.

8. INVESTMENT SUMMARY

The table below gives an estimate of the overall investment requirement in the electricity sector up to 2030. Note that the cost of the committed generation from 2011 to 2015 has not been included, and that the costs have been assumed for generation in 2029 and 2030, to cover the cost of plant under construction in those years but commissioned after 2030. The cost of generation connection to the grid has also not been included.

Table 26 Estimated Overall Investment

	Investment Cost - US$ Millions				
	Short Term	Long Term			
	2011-2015	2016-2020	2021-2025	2026-2030	2016-2030
Generation	Mega Deal etc.	11,000	10,269	10,800	32,069
Transmission (1)	3,000	1,387	1,844	2,633	5,864
Distribution - Rehabilitation	8,549				
Distribution - Expansion	4,644	3,910	5,132	7,699	16,741
Totals		16,297	17,245	21,132	54,674
(1) Scenario C with thermals - Base forecast					

On this basis, the estimated cost of transmission and distribution from 2011 to 2015 is about US$16 billion, and committed generation can be expected to add about US$ 10 billion to this. From 2016 to 2030 about another US$ 55 billion is required. The investment required is huge, particularly up to 2015, in which period rehabilitating the system and increasing the supply to meet the unsuppressed demand increases the level of investment needed.