Republic of Iraq

Ministry of Water Resources

General Directorate for Water Resources Management

Strategy for Water and Land Resources in Iraq

Guidance Note Series

Hydropower Spreadsheet

GN 08

This document was prepared under the Agriculture Reconstruction and Development Program Strategy for Water and Land Resources in Iraq Component (RAN-C-00-4-00002-00) by Development Alternatives Inc, August 2006.

This document is one of a series of occasional guidance notes published by the Ministry of Water Resources addressing issues relevant to strategic planning for the sustainable use of the water and land resources of Iraq.

The guidance note examines the hydropower potential in Iraq.

Report Issue and Revision Record

Rev	Date	Description
P1	August 2006	Preliminary when Phase 1 curtailed

List of Contents

Page

List of Tables

1 INTRODUCTION

1.1 Scheme Summary Sheet

Assumptions

1.1.1 The installed capacity, annual energy generation, annual hours of generation, static head values and expected capital costs have been obtained for the 7 existing and 68 potential hydropower stations in Iraq (Tables 1.1-1.8 present draft spreadsheets). These figures were obtained from a spreadsheet provided by the Ministry of Energy in Iraq. This data is assumed to be current and accurate; however there is limited information available regarding the assumptions used to create these estimates. It is uncertain when the cost estimates were developed and these could have changed substantially. It is assumed however that for cost comparison purposes this data is sufficient. The assumed operating rules are also unclear and may be driven by demand for irrigation flows. The level of consideration for the interaction of these issues is unclear and could have a substantial impact on costs and benefits associated with the hydropower schemes. With these issues in mind, the data from the table has been used to give an indication of some of the possible scenarios for hydropower development in Iraq from now until 2030. As the accuracy of the input data is improved, the scenarios can be updated and more accurate conclusions can be reached.

1.1.2 Using the installed capacity and static head with assumptions for turbine and generator efficiency and headlosses in the system, the flow required to produce this power was calculated. Using the number of hours of annual generation, the total yearly flow has been calculated. The annual energy generation and the number of hours of annual generation appear to assume that the station is only operated at rated capacity which is unlikely to be the case at all times, particularly if the flow is controlled by irrigation requirements as is currently the case for most hydropower schemes in Iraq.

1.1.3 The expected construction period has been estimated based on the installed capacity and Mott MacDonald's past experience for the purposes of planning when the various schemes could potentially be commissioned. Bekhme Power Station, which is expected to be the first plant commissioned, is already partially constructed and as such the estimated construction period is that required to finish the construction. Staff from the Ministry of Water Resources indicated that this station is hoped to be commissioned by 2010. If this is unachievable it is expected the scheme would be included in the 2015 scenario.

Recommended Usage

1.1.4 The scheme summary sheet should be used to get an impression of the potential for hydropower development in Iraq as well as approximate power and energy production that could be obtained at different sites and the water required to

produce this. The spreadsheet should be updated with more accurate data as it becomes available, for example as pre-feasibility and feasibility studies of these potential schemes are carried out.

1.1.5 The installed capacity, annual energy production and annual water requirements given in the scheme summary sheet, will be the main inputs for the optimisation model that has been developed. The scheme summary spreadsheet can also be used to understand some issues which may influence the construction programme of the potential schemes. This includes the scheme location, comparison between unit costs as well as approximate expected construction period.

1.2 Scenario Sheet

Assumptions

1.2.1 The scenario sheet (see Table 1.9) is based on the following key data and assumptions:

- The existing power and energy demand in Iraq;
- The rate of growth of power and energy demand in Iraq;
- The percentage of the total energy production which is currently being achieved by hydropower; and
- The expected change in this percentage from now to 2030.

1.2.2 This data has been sourced from spreadsheets developed by the ministry of energy containing 2005 data.

Data used

1.2.3 From the previously discussed spreadsheet containing summary information for the potential schemes, the following key data has been used to select the schemes which form each of the 5 year scenarios:

- Annual energy generation;
- Rated power output;
- Unit cost;
- Location; and
- Construction period.

Limitations and assumptions of data used

- Rated power output not as important for determining the number of new schemes required as annual energy generation was unit cost only comparative

- Location - north vs south
- Construction period not really used to choose schemes just to make sure is viable, particularly for 2010 case.

Development of Scenarios

1.2.4 Include how scenarios developed- how much energy needed? How much of that might come from hydropower? Which stations might be able to meet this demand? Stations selected based on size (bigger usually better), unit cost, location (balance between north & south)

Limitations

1.2.5 Problems with this are that if multi purpose schemes, as most in Iraq are, the decision on which dams to build may be based more on where the irrigation water is needed rather than the financials of the hydropower project. For a multi purpose scheme the project financials should also include the costs and benefits of the irrigation component which has not been included in the cost estimates used here.

1.3 Recommended Usage

1.3.1 How should future scenarios be developed?

1.3.2 What info needs replacing?

Table 1.1: Hydropower Potential in Iraq-Euphrates River Basin

Hydropower Potential in Iraq- Euphrates River Basin

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Euphrates River Basin	Rawa	Euphrates	330	*2354*	830	*676*	*21316*	18	2515	*29%*	165	135	1000	*7*	165	500	*5*
Euphrates River Basin	Al-Baghdadi	Euphrates	400	*1511*	1250	*539*	*16996*	34	3125	*36%*	102.5	500	800	*2*	220	550	*5.5*
Euphrates River Basin	Hit-1	Euphrates	50	*1284*	215	*630*	*19879*	5	4300	*49%*	68.5	68	40	*1*	55	1100	*3.5*
Euphrates River Basin	Hit-2	Euphrates	65	*1325*	280	*652*	*20558*	6	4310	*49%*	68.5	10	50	*5*	54	830	*4*

Notes:
1. Values in italics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.
5. These calculations assume the station is operated at rated capacity only. In reality this is unlikely.

Source:
1. Some data for the existing schemes was taken from a table provided by the Iraq Ministry of Water Staff "Design Capacity for Hydropower in Iraq" (Provided at meeting in Cambridge)
2. Key data for existing and potential schemes was taken from a table provided by the Iraq Ministry of Energy "Basic Parameters of Hydropower Schemes in Iraq with a Capacity Over 10 MW" (Obtained from the Extranet)

Assumptions:
1. For the potentail schemes the flow has been calculated using the power equation with an assumed 10% headloss, 90% turbine efficiency and 98% generator efficiency.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.2: Hydropower Potential in Iraq-Tigris River Basin

Hydropower Potential in Iraq- Tigris River Basin

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Tigris River Basin	Nineveh-1	Tigris	300	*1427*	900	*489*	*15410*	27	3000	*34%*	244	43	350	*8*	120	450	*5*
Tigris River Basin	Nineveh-2	Tigris	20	*642*	90	*330*	*10402*	4	4500	*51%*	217	7	20	*3*	24		*3*
Tigris River Basin	Khamam	Tigris	240	*1401*	720	*480*	*15130*	22	3000	*34%*	212	25	110	*4*	170	710	*5*
Tigris River Basin	Nimrud	Tigris	80	*1141*	230	*375*	*11814*	9	2875	*33%*	199	5	20	*4*			*4.5*
Tigris River Basin	Qaiyara	Tigris	420	*2345*	1380	*879*	*27732*	23	3285	*38%*	190	38	150	*4*	220	524	*5.5*
Tigris River Basin	Qaiyara Diversion	Tigris	400	*2233*	1230	*784*	*24723*	23	3075	*35%*	190	15	70	*5*			*5.5*
Tigris River Basin	Assur	Tigris	415	*2221*	1350	*824*	*25980*	24	3250	*37%*	167	27	100	*4*	270	650	*5.5*
Tigris River Basin	Assur Diversion	Tigris	400	*2140*	1220	*855*	*26967*	24	3500	*40%*	167	15	50	*3*			*5.5*
Tigris River Basin	Abassi	Tigris	200	*2568*	610	*894*	*28200*	10	3050	*35%*	143	20	80	*4*	130	650	*5*
Tigris River Basin	Makhul	Tigris	500	*3058*	1480	*1033*	*32581*	21	2960	*34%*	133	65	58	*1*	260	520	*5.5*
Tigris River Basin	Tikrit	Tigris	600	*2266*	1990	*858*	*27044*	34	3315	*38%*	112	50	235	*5*	420	700	*6*
Tigris River Basin	Tikrit-1	Tigris	300	*2568*	870	*850*	*26813*	15	2900	*33%*	112	13	65	*5*			*5*
Tigris River Basin	Tikrit-2	Tigris	280	*1892*	930	*717*	*22619*	19	3320	*38%*	97	17	85	*5*			*5*
Tigris River Basin	Daur	Tigris	170	*2183*	570	*835*	*26328*	10	3350	*38%*	78	20	90	*5*	120	706	*5*
Tigris River Basin	Samarra-1	Tigris	56	*599*	200	*244*	*7702*	*12*	3570	*41%*	68	*70*	*110*	*2*	20	360	*4*
Tigris River Basin	Samarra-2	Tigris	300	*2752*	1070	*1121*	*35366*	14	3570	*41%*	56	18	35	*2*	115	383	*5*
Tigris River Basin	Samarra-3	Tigris	80	*1468*	370	*674*	*21266*	7	4025	*46%*	42	15	70	*5*	85	1062	*4.5*
Tigris River Basin	Badush-1	Tigris	154	*1163*	497	*429*	*13514*	17	3227	*37%*	244	15	30	*220*	88	708	*5*
Tigris River Basin	Badush-2	Tigris	38	*610*	219	*401*	*12655*	8	5763	*66%*	227	15	8	*31*	48		*3.5*

Notes:
1. Values in itallics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.
5. These calculations assume the station is operated at rated capacity only. In reality this is unlikely.

Source:
1. Some data for the existing schemes was taken from a table provided by the Iraq Ministry of Water Staff "Design Capacity for Hydropower in Iraq" (Provided at meeting in Cambridge)
2. Key data for existing and potential schemes was taken from a table provided by the Iraq Ministry of Energy "Basic Parameters of Hydropower Schemes in Iraq with a Capacity Over 10 MW" (Obtained from the Extranet)

Assumptions:
1. For the potentail schemes the flow has been calculated using the power equation with an assumed 10% headloss, 90% turbine efficiency and 98% generator efficiency.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.3: Hydropower Potential in Iraq-Lesser Zab River Basin

Hydropower Potential in Iraq- Lesser Zab River Basin

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Lesser Zab River Basin	Osam	Kala Cholan	32	*34*	79	*10*	*305*	120	2470	28%	1200	16	230	*14*	19	762	*3.5*
Lesser Zab River Basin	Surba	Kala Cholan	24	*51*	71	*17*	*547*	60	2960	34%	1080	1	80	*80*	17	412	*3*
Lesser Zab River Basin	Nurabab	Kala Cholan	30	*70*	78	*21*	*656*	55	2600	30%	1020	4	70	*18*	20	250	*3.5*
Lesser Zab River Basin	Awa	Kala Cholan	65	*76*	163	*22*	*694*	110	2540	29%	965	3	40	*13*	40	432	*4*
Lesser Zab River Basin	Kili	Kala Cholan	80	*137*	207	*40*	*1253*	75	2540	29%	855	24	650	*27*	62	487	*4.5*
Lesser Zab River Basin	Mawat	Kala Cholan	120	*154*	260	*40*	*1270*	100	2290	26%	780	4	50	*12.5*	50	1000	*5*
Lesser Zab River Basin	Khazina	Kala Cholan	35	*150*	90	*43*	*1370*	30	2540	29%	680	1	10	*10*	24	900	*3.5*
Lesser Zab River Basin	Qala-Diza-1	Kala Cholan	300	*550*	700	*146*	*4616*	70	2330	*27%*	620	5	127	*25*	86	1074	*5*
Lesser Zab River Basin	Qala-Diza-2	Kala Cholan	165	*543*	500	*188*	*5926*	39	3030	*35%*	550	20	355	*18*	110	765	*5*
Lesser Zab River Basin	Taq-taq	Kala Cholan	400	*685*	980	*192*	*6041*	75	2450	*28%*	415	80	2400	*30*	210	940	*5.5*
Lesser Zab River Basin	Altun Kupri	Kala Cholan	300	*494*	1200	*226*	*7112*	78	4000	*46%*	340				190	773	*5*

Notes:
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2. Currently have no static head figures for greyed out schemes so can't calculate flows.
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Assumptions:
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2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.4: Hydropower Potential in Iraq-Greater Zab River Basin

Hydropower Potential in Iraq- Greater Zab River Basin

Region	Hydro/Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Greater Zab River Basin	Bekhme	Greater Zab	1500	#DIV/0!	4800	#DIV/0!	#DIV/0!		3200	37%	587	200	14000	*70*	1144	762	*4*
Greater Zab River Basin	Amadiya	Greater Zab	900	#DIV/0!	1780	#DIV/0!	#DIV/0!		1980	23%	460	19	900	*47*	371	412	*6.5*
Greater Zab River Basin	Rashawa	Greater Zab	550	#DIV/0!	980	#DIV/0!	#DIV/0!		1780	20%	710	3	72	*24*	137	250	*6*
Greater Zab River Basin	Bawn	Greater Zab	220	#DIV/0!	620	#DIV/0!	#DIV/0!		2820	32%	635	4	73	*18*	95	432	*5*
Greater Zab River Basin	Mandawa	Greater Zab	480	#DIV/0!	2240	#DIV/0!	#DIV/0!		4665	53%	394	80	2200	*28*	234	487	*5.5*
Greater Zab River Basin	Halwan	Greater Zab	200	#DIV/0!	1020	#DIV/0!	#DIV/0!		5100	58%	317			#DIV/0!	200	1000	*5*
Greater Zab River Basin	Eski Kelek with Ifraz weir	Makhmur Main Canal	100	#DIV/0!	408	#DIV/0!	#DIV/0!		4080	47%	278.5			#DIV/0!	90	900	*4.5*
Greater Zab River Basin	Nahola	Shamdenan	140	#DIV/0!	280	#DIV/0!	#DIV/0!		2000	23%	860	7	350	*50*	120	857	*5*
Greater Zab River Basin	Taili with Murak Hydros	Shamdenan/ W. Balka	300	#DIV/0!	606	#DIV/0!	#DIV/0!		2020	23%	718	11	520	*47*	185	617	*5.5*
Greater Zab River Basin	Shushan	Barazgir	25	#DIV/0!	65	#DIV/0!	#DIV/0!		2600	30%	900	1	5	*5*	14	560	*3*
Greater Zab River Basin	Shush	Barazgir	15	#DIV/0!	38	#DIV/0!	#DIV/0!		2535	29%	800		1	#DIV/0!	9	600	*2*
Greater Zab River Basin	Kulla	Barazgir	18	#DIV/0!	46	#DIV/0!	#DIV/0!		2555	29%	740		12	#DIV/0!	24	1333	*2.5*
Greater Zab River Basin	Khomari with Haji Bak Hydros	Barazgir	65	#DIV/0!	130	#DIV/0!	#DIV/0!		2000	23%	685	23	585	*25*	64	985	*4*
Greater Zab River Basin	Silem	Rawanduz	30	#DIV/0!	56	#DIV/0!	#DIV/0!		1865	21%	935	3	117	*39*	66	2200	*3.5*
Greater Zab River Basin	Omarawa	Rawanduz	18	#DIV/0!	34	#DIV/0!	#DIV/0!		1890	22%	820	1	6	*6*	15	833	*2.5*
Greater Zab River Basin	Bairus	Rawanduz	53	#DIV/0!	109	#DIV/0!	#DIV/0!		2055	23%	755	4	130	*33*	130	2450	*4*
Greater Zab River Basin	Jindian	Rawanduz	18	#DIV/0!	42	#DIV/0!	#DIV/0!		2335	27%	625	1	1	*1*	10	555	*2.5*
Greater Zab River Basin	Nila	Balikian	30	#DIV/0!	55	#DIV/0!	#DIV/0!		1835	21%	800	8	183	*23*	54	1800	*3.5*
Greater Zab River Basin	Shiwan	Balikian	15	#DIV/0!	30	#DIV/0!	#DIV/0!		2000	23%	722	1	5	*5*	11	733	*2.5*
Greater Zab River Basin	Dirana	Balikian	21	#DIV/0!	44	#DIV/0!	#DIV/0!		2095	24%	685		5	#DIV/0!	16	762	*3*
Greater Zab River Basin	Kholarash	Balikian	20	#DIV/0!	47	#DIV/0!	#DIV/0!		2350	27%	635		1	#DIV/0!	10	500	*3*
Greater Zab River Basin	Bakurman with Khalikan Dam	Khazir	70	#DIV/0!	80	#DIV/0!	#DIV/0!		1145	13%	574.5	20	490	*25*	67	957	*4.5*
Greater Zab River Basin	Lower Bakurman	Khazir	27	*87*	30	*11*	*346*	40	1110	*13%*	470	1	10	*10*	29	1074	*3.5*
Greater Zab River Basin	Safiya	Greater Zab	170	*1092*	510	*374*	*11789*	20	3000	*34%*	248	9	60	*7*	130	765	*5*
Greater Zab River Basin	Quwair- 1	Greater Zab	85	*910*	290	*354*	*11166*	12	3410	*39%*	228	8	40	*5*	80	940	*4.5*
Greater Zab River Basin	Quwair- 2	Greater Zab	85	*910*	290	*353*	*11134*	12	3400	*39%*	216	12	50	*4*	80	940	*4.5*
Greater Zab River Basin	Quwair- 3	Greater Zab	110	*1009*	370	*387*	*12205*	14	3360	*38%*	204	13	70	*5*	85	773	*4.5*

Notes:
1. Values in itallics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.
5. These calculations assume the station is operated at rated capacity only. In reality this is unlikely.

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Assumptions:
1. For the potentail schemes the flow has been calculated using the power equation with an assumed 10% headloss, 90% turbine efficiency and 98% generator efficiency.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.5: Hydropower Potential in Iraq-Khabur River Basin

Hydropower Potential in Iraq- Khabur River Basin No static head values!!

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Khabur River Basin	Besar	Khabur	50	#DIV/0!	180	#DIV/0!	#DIV/0!		3600	*41%*	925	3	82	*27*	60	1200	*4*
Khabur River Basin	Riwan	Khabur	130	#DIV/0!	275	#DIV/0!	#DIV/0!		2115	*24%*	820	20	817	*41*	102	785	*5*
Khabur River Basin	Basi	Khabur	70	#DIV/0!	174	#DIV/0!	#DIV/0!		2485	*28%*	703	3	45	*15*	410	586	*4*
Khabur River Basin	Kufaki	Khabur	70	#DIV/0!	156	#DIV/0!	#DIV/0!		2230	*25%*	640	5	14	*3*	43	614	*4*
Khabur River Basin	Dalal	Khabur	110	#DIV/0!	245	#DIV/0!	#DIV/0!		2230	*25%*	590	16	385	*24*	79	718	*4.5*
Khabur River Basin	Dola	Khabur	120	#DIV/0!	265	#DIV/0!	#DIV/0!		2210	*25%*	518	4	40	*10*	67	558	*4.5*
Khabur River Basin	Zakho	Khabur	100	#DIV/0!	230	#DIV/0!	#DIV/0!		2300	*26%*	450	2	12	*6*	60	600	*4.5*
Khabur River Basin	Bajuka	Khabur	150	#DIV/0!	370	#DIV/0!	#DIV/0!		2465	*28%*	395	5	25	*5*	70	467	*4.5*

Notes:
1. Values in itallics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.
5. These calculations assume the station is operated at rated capacity only. In reality this is unlikely.

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2. Key data for existing and potential schemes was taken from a table provided by the Iraq Ministry of Energy "Basic Parameters of Hydropower Schemes in Iraq with a Capacity Over 10 MW" (Obtained from the Extranet)

Assumptions:
1. For the potentail schemes the flow has been calculated using the power equation with an assumed 10% headloss, 90% turbine efficiency and 98% generator efficiency.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.6: Hydropower Potential in Iraq-Diyala River Basin

Hydropower Potential in Iraq- Diyala River Basin No static head values!!

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Diyala River Basin	Tongar	Diyala	155	#DIV/0!	450	#DIV/0!	#DIV/0!		2905	*33%*	380	8	110	*14*	100	645	*4.5*
Diyala River Basin	Bebas	Diyala	110	#DIV/0!	370	#DIV/0!	#DIV/0!		3365	*38%*	335	31	440	*14*	110	1000	*4.5*
Diyala River Basin	Bawanur	Diyala	175	#DIV/0!	550	#DIV/0!	#DIV/0!		3145	*36%*	302	11	170	*15*	150	857	*5*
Diyala River Basin	Sankar	Diyala	110	#DIV/0!	350	#DIV/0!	#DIV/0!		3180	*36%*	250	8	30	*4*	70	636	*4.5*
Diyala River Basin	Kalar	Diyala	105	#DIV/0!	320	#DIV/0!	#DIV/0!		3050	*35%*	215			#DIV/0!	80	762	*4.5*
Diyala River Basin	Qara Teppe	Diyala	245	#DIV/0!	730	#DIV/0!	#DIV/0!		2980	*34%*	181			#DIV/0!	160	653	*5*
Diyala River Basin	Qara Teppe-1	Diyala	105	#DIV/0!	310	#DIV/0!	#DIV/0!		2950	*34%*	181			#DIV/0!	100	952	*4.5*
Diyala River Basin	Qara Teppe-2	Diyala	140	#DIV/0!	420	#DIV/0!	#DIV/0!		3000	*34%*	148			#DIV/0!	60	428	*4.5*

Notes:
1. Values in itallics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.
5. These calculations assume the station is operated at rated capacity only. In reality this is unlikely.

Source:
1. Some data for the existing schemes was taken from a table provided by the Iraq Ministry of Water Staff "Design Capacity for Hydropower in Iraq" (Provided at meeting in Cambridge)
2. Key data for existing and potential schemes was taken from a table provided by the Iraq Ministry of Energy "Basic Parameters of Hydropower Schemes in Iraq with a Capacity Over 10 MW" (Obtained from the Extranet)

Assumptions:
1. For the potentail schemes the flow has been calculated using the power equation with an assumed 10% headloss, 90% turbine efficiency and 98% generator efficiency.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.7: Hydropower Potential in Iraq-Adhaim River Basin

Hydropower Potential in Iraq- Adhaim River Basin No static head values!!

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)	Expected Construction Period
Adhaim River Basin	Damir Kapu	Adhaim	40	*#DIV/0!*	200	*#DIV/0!*	*#DIV/0!*		5000	*57%*	135	105	1400	*13*	67	1675	*3.5*

Notes:
1. Values in itallics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.
5. These calculations assume the station is operated at rated capacity only. In reality this is unlikely.

Source:
1. Some data for the existing schemes was taken from a table provided by the Iraq Ministry of Water Staff "Design Capacity for Hydropower in Iraq" (Provided at meeting in Cambridge)
2. Key data for existing and potential schemes was taken from a table provided by the Iraq Ministry of Energy "Basic Parameters of Hydropower Schemes in Iraq with a Capacity Over 10 MW" (Obtained from the Extranet)

Assumptions:
1. For the potentail schemes the flow has been calculated using the power equation with an assumed 10% headloss, 90% turbine efficiency and 98% generator efficiency.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.8: Existing Hydropower Developments in Iraq

Existing hydropower developments in Iraq

Region	Hydro/ Dam Name	River	Installed Capacity (MW)	Rated Discharge (m^3/s)	Annual Energy Generation (GWh/yr)	Average Annual Flow (m^3/s)	Total Yearly Flow (mill m^3/yr)	Static Head (m)	No of Machines	No. Hours Operation / Year	Capacity Factor	NMOL (m)	Reservoir Water Area (km^2)	Reservoir Full Storage Capacity (mill m^3)	Average Depth (m)	Capex (mill ID)	Unit Cost (ID/kW)
Euphrates River Basin	Haditha	Haditha	660	1980	1680	*578*	*18212*	44.5	6	2555	*29%*	147	500	8200	*16*	350	500
Tigris River Basin	Mosul-1	Tigris	750	1140	2420	*420*	*13235*	73.5	4	3225	*37%*	330	380	11110	*29*	400	494
Tigris River Basin	Mosul-2	Tigris	60	*808*	346	*531*	*16761*	11	*2*	5765	*66%*	256.5	4	21	*5*		
Tigris River Basin	Sammara Barrage	Tigris	80	1170	510	*811*	*25567*	12	3	6070	*69%*	68	70	110	*2*		
Lesser Zab River Basin	Dokan	Lesser Zab	400	550	1130	*178*	*5603*	96	5	2830	*32%*	511	270	6850	*25*		
Diyala Basin	Derbendekan	Diyala	166	240	610	*70*	*2195*		3	2540	*29%*	485	110	3000	*27*		
Diyala Basin	Hemrin	Diyala	50	200	250	*114*	*3600*		2	5000	*57%*	104	350	2600	*7*		
	Hindyqa Barrage		5						1			31.9					

So Haditha uses approximately 1980 m^3/s for approximately 3 months of the year, presumably during the wet season, and has a total yearly flow of 18,212 mill m^3

Notes:
1. Values in itallics were calculated or assumed values (not provided in tables from Iraq)
2. Currently have no static head figures for greyed out schemes so can't calculate flows.
3. ID= Iraqi Dollars
4. The static head will change as the stations are operated as the water level in the reservoir changes. This has not been accounted for here.

Source:
1. Some data for the existing schemes was taken from a table provided by the Iraq Ministry of Water Staff "Design Capacity for Hydropower in Iraq" (Provided at meeting in Cambridge)
2. Key data for existing and potential schemes was taken from a table provided by the Iraq Ministry of Energy "Basic Parameters of Hydropower Schemes in Iraq with a Capacity Over 10 MW" (Obtained from the Extranet)

Assumptions:
1. Where flow not available, assume 10% headloss, 0.85 turbine efficiency and 0.9 generator efficiency for power calc.
2. Construction periods taken from graph in James Arthur's hydropower presentation.

Table 1.9: Forecast Hydropower Energy and Power Requirements and Possible Scenarios

Forecast Hydropower Energy and Power Requirements and Possible Scenarios

	Additional Energy Demand (GWh)	% of Total Energy Demand which could be met by Hydropower	Additional Hydropower Energy Demand (GWh)	Potential Schemes to be Constructed	Energy (GWh/yr)
2005 - 2010	22,444	20%	**4,489**	Bekhme	4,800
2010 - 2015	31,479	18%	**5,666**	Samarra-1	200
				Samarra-2	1,070
				Nineveh-1	900
				Nineveh-2	90
				Rawa	830
				Qaiyara	1,380
				Qaiyara Diversion	1,230
2015 - 2020	44,152	16%	**7,064**	Makhul	1,480
				Al-Baghdadi	1,250
				Assur	1,350
				Assur Diversion	1,220
				Altun Kupri	1,200
				Kili	207
2020 - 2025	61,925	14%	**8,669**	Abassi	610
				Tikrit	1,990
				Tikrit-1	870
				Tikrit-2	930
				Daur	570
				Badush-1	497
				Badush-2	219
				Khamam	720
				Nimrud	230
				Safiya	510
				Quwair- 1	290
				Quwair- 2	290
				Taq-taq	980
2025 - 2030	86,853	12%	**10,422**	Qala-Diza-1	700
				Qala-Diza-2	500
				Quwair- 3	370
				Amadiya	1,780
				Rashawa	980
				Bawn	620
				Mandawa	2,240
				Halwan	1,020
				Taili with Murak Hydr	606
				Tongar	450
				Qara Teppe	730
				Qara Teppe-2	420

	Additional Power Demand (MW)	% of Total Power Demand which could be met by Hydropower	Additional Hydropower Power Demand (MW)	Potential Schemes	Power (MW)
2005 - 2010	3,061	20%	**612**	Bekhme	1,500
2010 - 2015	4,293	18%	**773**	Samarra-1	56
				Samarra-2	300
				Nineveh-1	300
				Nineveh-2	20
				Rawa	330
				Qaiyara	420
				Qaiyara Divers	400
2015 - 2020	6,021	16%	**963**	Makhul	500
				Al-Baghdadi	400
				Assur	415
				Assur Diversio	400
				Altun Kupri	300
				Kili	80
2020 - 2025	8,444	14%	**1,182**	Abassi	200
				Tikrit	600
				Tikrit-1	300
				Tikrit-2	280
				Daur	170
				Badush-1	154
				Badush-2	38
				Khamam	240
				Nimrud	80
				Safiya	170
				Quwair- 1	85
				Quwair- 2	85
				Taq-taq	400
2025 - 2030	11,843	12%	**1,421**	Qala-Diza-1	300
				Qala-Diza-2	165
				Quwair- 3	110
				Amadiya	900
				Rashawa	550
				Bawn	220
				Mandawa	480
				Halwan	200
				Taili with Mura	300
				Tongar	155
				Qara Teppe	245
				Qara Teppe-2	140

Notes:
Annual energy production is factor determining plants to be implemented, not installed capacity