SECTION 2

PROJECT BACKGROUND AND PROJECT DESCRIPTION

2   PROJECT BACKGROUND AND PROJECT DESCRIPTION

2.1   The GAP Project

The Southeastern Anatolia Project (GAP) was initiated in 1991 to improve the living standards, develop the agricultural potential of the 8 southeastern Anatolia provinces (GAP-Region) and bring them to the level of national socioeconomic averages. The project covers a land area corresponding to 9.5% of the national territory in which 8.5% of the total Turkish population lives. The GAP is the largest development project ever undertaken in Turkey. It pursues the following main objectives are [264]:

Revitalize the regional economies, speed up the land development and agricultural expansion, and improve the irrigation efficiency, in order to increase employment and revenues.

Give priority to the completion of infrastructure projects in major cities which will become attractive centers in near future: drinking and industrial water supplies, sewage networks, waste water treatment plants, solid waste disposal and power distribution. Furthermore design and implementation of the infrastructure projects which can meet the needs of the rapid regional population increase expected in the coming years.

Develop the hydro potential of the Euphrates and Tigris basins with the construction of dams and hydropower plants, in order to increase the share of national resources in the energy production sector.

Improve the energy transmission and distribution.

Promote agricultural development programs related to soil and water resource development, on-farm development services, land consolidation and upgrading as well as seed production and distribution.

Build all infrastructures needed by agro-industries including small scale industrial estates and organized industrial zones.

Improve the education and health services, encourage the construction of boarding regional schools and education systems supported by adequate means of transportation in order to solve some of the problems resulting from dispersed rural settlements.

Improve the main communication and transportation infrastructure.

Extend the efforts aiming at a better erosion control, reforestation and pasture improvement.

Other local development projects presently not included in the GAP are also considered in the this part of the country.

The main characteristics of the GAP together with those of the so-called Miscellaneous Projects are given in Table 2-1 while an overview is summarized in the following Table:

	Projects and units	Installed capacity [MW]	Energy production [GWh]	Irrigated area [ha]
	Euphrates Basin, GAP Projects			
1	Karakaya Project	1'800	7'354	-
2	Lower Firat Project	2'450	9'024	702'595
3	Sinir Firat Project	861	3'168	-
4	Suruç-Yaylak Project	-	-	114'826
5	Adiyaman-Kahta Project	195	509	77'824
6	Adiyaman-Göksu-Araban	7	43	71'598
7	Gaziantep Project	-	-	142'664
	Total Euphrates Basin, GAP Projects	**5'313**	**20'098**	**1'109'507**
	Miscellaneous Euphrates Basin	**14**	**42**	**70'365**
	Tigris Basin, GAP Projects			
8	Kralkizi-Dicle Project	204	444	130'159
9	Batman Project	198	483	37'351
10	Batman-Silvan Project	240	964	257'000
11	Garzan Project	90	315	60'000
12	Ilisu Project	1'200	3'833	-
13	Cizre Project	240	1'208	121'000
	Total Tigris Basin, GAP projects	**2'172**	**7'247**	**605'510**
	Miscellaneous Tigris Basin	**0**	**0**	**31'748**
	Total GAP, Euphrates and Tigris Basins	7'485	27'345	1'715'017
	Total Miscellaneous, Euphrates and Tigris Basins	14	42	102'113
	Grand Total Euphrates and Tigris	**7'499**	**27'387**	**1'817'130**

For the Euphrates and Tigris basins together, in total 22 dams and 19 Hydroelectric Powerplants are foreseen in the frame of the GAP and 18 dams and 12 HEPP in the frame of Miscellaneous Projects.

The total costs of the GAP are estimated at 32'000 M$ distributed as follows:

Type of project	[%]
Energy	32
Agriculture	30
Transport and communication	22
Housing, education, health, other public services	8
Others	8

At the end of 1999, the investments had reached 14'000 M$ or 44% of the total [265].

The production of the GAP powerplants contributed in 1999 more than 40% of Turkey's hydraulic energy production or nearly 13% of Turkey's total production.

In June 2000, 64% of the planned power capacity were in operation and 10% under construction [265], 12% of the contemplated irrigation facilities were in operation, 8% under construction and 25% ready for contracting [265]. The experience of the first 5 years of irrigation in the Harran plain show that the gross agricultural output (yield x unit price) has doubled and the value added (output – production costs) has increased by a factor of more than 2.5 if compared to the results before irrigation.

With respect to regional planning and coordination between the relevant institutions, GAP-RDA administer the Project and are involved with the general water resources and irrigation projects infrastructure, the construction of water supply projects, including industrial development, promotion of commercial fishery, reforestation and recreation facilities. The implementation schedule of the GAP extends currently until 2017 but is currently adapted to the finances and managerial capacities of the country. Special emphasis has been granted in the last years to better enhance the sustainability of the different components of the overall Project

2.2 The electrical energy situation in Turkey

2.2.1 Installed capacity, consumption and growth forecasts

With an overall installed capacity of 21'334 MW, the power production in Turkey amounted to about 96'000 GWh per year in 1998, out of which 47% was of hydro origin. Consumption has quickly increased during the last years and, according to TEAS forecasts the demand will continue to increase in the near future at a rate of about 8% per year. The reasons for this rapid development are the population growth and urbanization as well as the ongoing industrialization and improvement of the living standards. Nevertheless, the prediction for the energy consumption per person for year 2010 remains only about half of the present value for western Europe. In order to comply with the increasing demand, it would be necessary to add an installed capacity of 2'500 MW per year.

2.2.2 Hydropower development in Turkey

In spite of all the efforts spent in the recent years for meeting the rapidly increasing energy demand, the production could not follow the economical development of the country, and all forecasts concur that this will remain so, at least for the next years. Apart from the direct economical damage and the impact on the living standard, significant energy shortages would also perturb the economical and political stability. Furthermore, Turkey's policy endeavors nevertheless to limit the commercial and strategic risks inherent to a high dependence on imported fuel for the following reasons:

The potential of hydropower is presently less than 30% developed. The actual energy planning puts therefore much emphasis on the development of about 1000 MW of hydropower per year. Nevertheless, the share of hydropower will decrease during the next few years and the use of fossil fuel will irreversibly increase more rapidly.

Hydropower development represents an opportunity to promote the economical development of southeastern Anatolia by implementing important hydroprojects generating regional spin-off's.

Hydropower is not penalized by the direct economical damage generated by imported fuels and by the danger of restriction in case of an oil crisis which would impair the country's development, a prerequisite for political stability.

Hydropower is a fully controlled technology to produce large amounts of energy according to the actual instant demand with very little emission of greenhouse gases. It does not need sunshine nor wind but just head and a large amount of water, 2 components available in Turkey.

As the development of agriculture in the Tigris basin is one of the main objectives of the GAP, the seasonal storage of the large river discharges recorded in spring time is mandatory to increase the flows during the dry season. The coordinated development of agriculture and hydropower makes it possible to take advantage of favorable synergies.

2.2.3 Alternative energy production

Apart from hydropower, the other energy resources of Turkey are fossil fuel (lignite, hard coal, asphaltite, oil, natural gas) which are however by far insufficient to cover the needs. Based on long term import agreements with Russia and Middle East countries, large amounts of fossil fuel must be imported.

As alternative to hydro development, fossil fueled plants could be considered, either based on imported gas, oil or coal. Given the size and purpose of the Project, the operation of an alternative oil-fired plant would require the annual transport and incineration of about 1 Mt of oil, i.e. about 2'500 t per day, releasing therewith 3 Mt CO_2 and 76'000 t SO_2 per year. With a coal fired powerplant, approximately 1.7 Mt of combustible would be needed and about 300'000 t of ashes would have to be disposed yearly.

All fossil fueled powerplants contribute to local air pollution and to the emission of greenhouse gases. The impact on local air quality (particulate, sulfur dioxide and nitrogen oxides) strongly depends on the fuel quality but also on the emission control and operation of such plants.

About half of the greenhouse gas emitted worldwide is CO_2 and most of it (80%) is related to thermal energy production. The emissions at present are in the order of 22'000 Mt of CO_2 annually. Replacing the Ilisu powerplant by a fossil fueled plant producing the same amount of energy, would contribute to about 0.01% of the worldwide CO_2 emission. Depending on the combustion source used as alternative for Ilisu, the following indicative emission rates would result:

Fuel type	CO_2 [Mt/year]
Lignite	~5
Coal	~4
Oil	~3
Gas	~2

In a reservoir, the production of greenhouse gases is proportional to the organic material flooded and to the concentration of carbon per unit weight. Depending on the rate of decomposition of the organic components, the emission coefficient varies between 25 and 70 g of CO_2 equivalent /kWh compared to 600 g CO_2 equivalent for gas turbines.

The use of photovoltaic and wind energy are not advanced in Turkey and cannot represent competitive alternatives for large plants. An equivalent installed capacity of 1'200 MW would require numerous photovoltaic installations. Each one could generate between 1 and 4 MW and would require a surface of 20'000 m^2 per installed MW, including maintenance and auxiliary facilities. If peak energy is needed, a large portion of this energy, which is produced during the day, would have to be stored in batteries kept in a special designed ventilated building for maintaining the level of acid fumes to an acceptable level. The building must be within the compound and include a control room equipped with remote operation tools. Each installation has to be connected to the 34.5 or 15 kV network. This means that approximately 600 plants would have to be erected and remotely controlled, making it more difficult for the Operator to manage the system.

The localization of these photovoltaic facilities would need to be optimized in areas where the duration of sunshine is highest. The installations need to be cleared of trees in a perimeter sufficient to allow maximum sun radiation to be absorbed by the panels. The produced energy is more expensive than that from hydropower. Rough estimates are in the order of 2'500 $ per installed kW for hydropower compared to 8'500 $/kW for photovoltaic.

Maintenance is also expensive and time consuming. It includes periodic cleaning of the panels, monthly inspections of the electrolytes in the batteries and a thorough control of vegetation growth of the entire compound and beyond. For a 4 MW generating station, the number and size of the batteries required is impressive and the batteries have a life expectancy of only 5 to 10 years at the utmost after which they have to be replaced. Environmentally, photovoltaic plants do not generate greenhouse gasses in the atmosphere but the complete cycle of production and disposal of the panels however produces the equivalent of 47'203 kg of CO2 per TJ of power produced [271].

Solar energy can therefore be seriously considered today in Turkey only for remote areas where electricity distribution is deficient or not existing, for islands with low population densities or for remote telecommunication installations.

Another renewable source comes from the wind energy. Presently, 39 areas are being studied in Turkey where wind conditions would permit the installation of wind turbine generating facilities. These areas are generally located on top of hills at a certain distance from the sea where warm continental air meets colder masses coming from the sea. The production is dependent upon the frequency and velocity of the wind and varies accordingly. More than 1'200 very large wind generators would be needed to have an installed capacity equal to that of Ilisu. For maintenance, it would be necessary to regroup the wind generators in so-called "wind farms" of 10 or more turbines. The 39 projects being presently investigated in Turkey would have a generating capacity of approximately 1'400 MW.

It is obvious that wind generators are not adequate for peak energy due to the random characteristic of the operation hours. Another source is always needed to fill in when the wind turbines cannot be operated due to the absence of wind. Wind energy projects combined with Ilisu could be complementary and would contribute to cover the demand increase of one year only, while Ilisu could fill for the absence of wind generation under unfavorable wind conditions.

The cost of generating electricity from windmill is more than that of hydro and the environmental impacts are not negligible. The localization of wind farms must be optimized outside areas valued by the population. In addition, wind turbines generate low frequency vibrations that are annoying for the people living nearby. Bird mortality has occasionally been important and some of the species impacted are on the IUCN Red List.

Turkey investigated also the implementation of nuclear powerplants for more than 20 years and wanted to proceed to the construction of the first one at Akkuyu, in the Mersin Province but froze the project in the summer of 2000.

2.2.4 Improvement potential of the high voltage transmission network

The "electrical" losses of a transmission network are basically ruled by the square of the current in the system. A reduction of these losses can be achieved using one or several of the following techniques:

Raising the transmission voltage.

Improving the meshing of the grid system.

Increasing the cross section of the transmission lines.

Installing adequate shunt reactors for reactive power compensation in the network.

In Turkey, the bulk energy transport from hydropower generation is made through 380 and 154 kV transmission lines interconnecting the hydropower production plants in the south-eastern parts of the county with the large consumer centers located in the north-western provinces.

In order to improve their transmission system parameters and to raise their overall system efficiency, some large countries with long distance transmission lines like Argentina, Brazil, Canada, Chile, Colombia, Iran, Japan, Russia, South Africa and the USA have therefore built up part of their networks with voltages higher than 400 kV.

The studies performed in Turkey since the eighties in view of the implementation of a long distance electric transmission network with 750-800 kV A.C. or 2 x 500 kV D.C. showed that the 800 kV A.C. alternative would be the most advisable. TEK (today TEAS) envisaged therefore seriously this alternative at the time of the Atatürk powerplant construction. However, after having estimated the huge investments involved for the required transformation of part of the existing system and after evaluating the ultimate cost/benefit relation, this alternative was momentary abandoned.

With the commissioning of the Keban (1'280 MW), Karakaya (1'800 MW) and Atatürk (2'400 MW) powerplants on the Euphrates, the transmission system losses increased beyond the comparable levels prevailing in West-European countries due to the insufficient transmission capacity of the 380 kV network. Subsequently, additional transmission lines were however built and compensation plants installed, resulting in a substantial improvement of the

relatively low system efficiency. Today, with few exceptions, the losses incurred in the Turkish transmission system remain certainly within acceptable levels (3÷5%). Still, some areas remain overloaded but TEAS authorities are fully aware of this problem and continue their efforts to improve the situation. It is clear that the integration of new hydropower plants into the production system will command the further improvement of the transmission network in future.

The 20÷30% energy losses mentioned by some circles are misleading because they include not only the transmission but also all the distribution losses and they refer apparently to the difference between the total gross production and the total net consumption figures. They are therefore not representative of the transmission system efficiency. In addition to the technically generated transmission losses, this difference includes also non-technical "commercial or trading" losses like tariff subsidies as well as income losses for unpaid or stolen energy. The expectable improvements of the transmission system, which will take years of efforts and substantial investments to save some MW on the transmission system losses, are in no case at scale with the production of a 1'200 MW powerplant like Ilisu.

2.2.5 Energy saving programs

Efforts are made by the State for promoting an efficient electricity consumption and energy saving methods. In the industrial and infrastructure sectors, the installation of so called "capacitor banks" is encouraged by applying incitative tariff policies. For the individual consumers, television sending and advertisement spots are focused on energy savings. Furthermore, the insulation of domestic, commercial and industrial buildings is encouraged and improved substantially during the last years with new licensing policy by the authorities.

2.3   Present and future use of the Tigris water resources in Turkey

The development of the Tigris River in Turkey has been initiated years after that of the Euphrates because the latter, with a catchment area of 121'000 km^2 in Turkey presents more favorable conditions for energy generation and the development of irrigated agriculture than the Tigris with a catchment area of about 41'000 km^2 in Turkey (without the Greater Zab or Zap originating in Turkey but discharging into the Tigris beyond the border). Actually, the Euphrates yields most of its discharges in Turkey and the discharges of the tributaries south of the border are relatively small, while the contribution of the Tigris tributaries beyond the Turkish border is very important as illustrated in the following Table:

Country	Tigris		Euphrates	
	[1'000 Mm^3/year]	[%]	[1'000 Mm^3/year]	[%]
Turkey	21.3	40.4	31.6	90.3
Syria	0.0	0.00	3.4	9.7
Iraq	31.4	59.6	0.0	0.0
Total	**52.7**	**100.0**	**35.0**	**100.0**

Today the use of the water resources of the Tigris basin in Turkey is for the largest part managed in the frame of the GAP.

The following Table summarizes the present situation of the development and forecasts of the water resources along the Turkish course of the Tigris (from upstream towards downstream) [233], [262]:

Project	Installed capacity [MW]	Energy production [GWh]	Irrigated area [ha]	GAP or MIS Status
Ergani Dam and Irrigation	-	-	1'861	MIS/PL
Kralkizi Dam and HEPP	94	146	-	GAP/OP
Dicle Dam and HEPP	110	298	-	GAP/OP
Dicle Right Bank Gravity Irrigation	-	-	54'279	GAP/PR+CO
Dicle Right Bank Pumping Irrigation (P2 and P5)	-	-	23'085	GAP/CO
Dicle Right Bank Pumping Irrigation (P6)	-	-	7'845	GAP/PR
Dicle Right Bank Pumping Irrigation (P3 and P4)	-	-	44'950	GAP/PR
Dicle Left Bank Gravity Irrigation	-	-	200'000	GAP/MP
Dicle Left Bank Pumping Irrigation	-	-	57'000	GAP/MP
Devegeçidi Dam and Irrigation	-	-	7'500	MIS/OP
Dilaver Dam and Çinar-Dilaver Irrigation	-	-	3'575	MIS/PL
Göksu Dam and Çinar-Göksu Irrigation	-	-	3'582	MIS/OP
Silvan Irrigation, Stages I + II	-	-	8'790	MIS/OP
Silvan Dam and HEPP	150	623	-	GAP/MP
Kayser Dam and HEPP	90	341	-	GAP/MP
Batman Dam and HEPP	198	483	-	GAP/IM
Batman Left Bank Irrigation	-	-	18'758	GAP/CO
Batman Right Bank Gravity Irrigation	-	-	18'593	GAP/CO
Garzan Dam and HEPP	90	315	-	GAP/RE
Garzan-Kozluk Irrigation	-	-	60'000	MIS/RE
Garzan Kozluk Irrigation	-	-	3'700	MIS/OP
Ilisu Dam and HEPP	1'200	3'833	-	GAP/PR
Cizre Dam and HEPP	240	1'208	-	GAP/PR
Nusaybin-Cizre-Idil Irrigation (D/S Cizre)	-	-	89'000	GAP/RE
Nerdus Irrigation (D/S Cizre)	-	-	2'740	MIS/OP
Silopi Plain Irrigation (D/S Cizre)	-	-	32'000	GAP/RE
Total Tigris Basin	**2'172**	**7'247**	**637'258**	

CO:	Construction	MIS:	Miscellaneous	RE:	Reconnaissance
FD:	Final Design	MP:	Master Plan	OP:	In operation
IM:	Impounding	PR:	In program	PL:	Planning

On the long term, 26 projects including 12 dams and 8 HEPP are anticipated to be implemented on Turkish territory in the Tigris basin, out of which 12 are in operation, construction or impounding stage, 4 in program (among which Ilisu and Cizre), 2 in planning stage and 8 in reconnaissance or Master Plan stage. The main characteristics of the dams and HEPP are summarized in Tables 2-2÷2-7.

Whenever all these projects would be implemented, the installed powerplant capacity would reach 2'172 MW, the annual energy production 7'247 GWh and the irrigated area 637'258 ha.

The irrigation needs for the projects in operation and presently under construction will amount to about 1'500 Mm^3/year, corresponding to around 10% of the mean annual flow at Ilisu. The irrigation needs for the fully developed potential area of the GAP upstream of the Ilisu reservoir will depend on the results of the relevant planning and Final Design investigations, on the selected crop breakdown as well as on the irrigation techniques applied at the time of implementation of the future projects. They will exceed the estimate in the Feasibility Report [163] which had been confirmed during the Final Design stage. Theoretically, assuming that all GAP irrigation projects upstream of Ilisu would be implemented on long term with the present irrigation technology, and considering that roughly 10÷15% of the irrigation needs flow back to the riverbeds, the flow reduction downstream caused by the hypothetical irrigation requirements upstream of Ilisu might therefore amount up to 4'300 Mm^3, corresponding to about 25% of the average Tigris runoff at Cizre.

It must however be kept in mind that 8 of the above projects are still in the reconnaissance or Master Plan stage so that the actual future developments might still be the object of substantial revisions in future. Furthermore, it must be also mentioned that the overall impact of future GAP irrigation projects on the river flow downstream of Ilisu will be less significant than the anticipated full development of the Euphrates basin in Turkey. This is due to the important difference of origin in the yield of the 2 rivers: At the confluence with the Euphrates, the Tigris inflows from Turkey (including the Greater Zab River originating also in Turkey) amount to 40% of the total, whilst those of the Euphrates account for 90% from Turkey [230].

Ilisu is a pure energy project with an installed capacity of 1'200 MW corresponding to 16 % of the overall GAP capacity. Its scheduled annual energy production of 3'833 GWh represents 14% of the total energy production of the GAP projects.

Downstream, the Cizre Project is planned for both power production (240 MW) and irrigation of 121'000 ha and its implementation should start after the green light to built Ilisu is given (Section 4.1.6.6).

The seasonal and annual flows of the Euphrates and Tigris Rivers have extremely high variance along all their courses (Section 3.1.3 for discussion of the Tigris basin). Two distinct dry cycles were recorded for the Euphrates over the 1937÷1993 period. The first was in 1958÷1962, the second started in 1970 and ended in 1975. On the Tigris River the annual average flow at Cizre near the Turkish border was 16'200 Mm^3 over the 1946÷1994 period [266]. The 1970÷1975 period experienced a drastic decline in the flow rate, the lowest being

in 1973 at 9'600 Mm^3. On the other hand, 1969 was a peak year with 34'300 Mm^3. The flow rates show also a significant seasonal variation. The highest discharges are generally observed from March to May, the lowest between August and October. The highest monthly flow in a 49-year period was a factor 5.3 above the long-term all-year average, the lowest a factor 8.7 below. Furthermore, the timing of the floods in the Euphrates and the Tigris does not fit well with the agricultural requirements because the floods are erratic and occur at the "wrong time", the period of April-June being too slightly late for the summer crops and too early for the winter crops [266], [267].

Because of the extremely high seasonal and annual fluctuations of the Euphrates and Tigris flows which have been a central water management problem for millennia, storage facilities represent the key elements of water resources management, for Turkey as well as for the downstream riparian countries. For topographical reasons, however, the water can more easily be stored in the upper catchment for regulating the flows throughout the year and over the years.

The flow characteristics of a river can be significantly changed by storage facilities. The attenuation of large floods and the provision of sufficient flow during drought periods is one of the objectives of the reservoir system on the Euphrates and Tigris Rivers in Turkey. Ilisu is part of this system but is a single purpose hydroelectric facility. It will contribute to the flood peak attenuation and increase the summer flows, as shown by model calculations in Section 4.1.6.5. This contribution will be beneficial for the downstream users and especially for the Cizre Project but Ilisu does not depend on the implementation of Cizre. General remarks on the influence of the Project on the downstream discharge pattern are presented in Sections 4.1.6.2. 4.1.7.3 and 4.1.6.6. It can be noticed, however, that floods will not be fully suppressed, but only reduced in peak magnitude and return frequency.

2.4   The Ilisu Project

2.4.1 General description of the Project

The Ilisu Project is located in southeastern Anatolia, between 37^0 30' 00" and 38^0 00' 00" latitude north and 40^0 44' 00" and 42^0 02' 00" longitude east. The rockfill dam and powerplant are located on the Tigris River, 45 km upstream the city of Cizre [30]. The dam will be 135 m high with a crest length of 1'820 m and will have a volume of 43.8 Mm^3. The Ilisu reservoir will cover a surface of 300 km^2 at normal storage level" (525 m) and 313 km^2 at maximum flood

level (526.80). It will extend over a length of 136 km along the Tigris valley. The tail of the reservoir will be located between Tepeköy and Bismil. The lower valley sections of the major tributaries (Batman River, Garzan River, Botan River) will also be flooded. The reservoir will flood the small hydroelectric plant on the Botan in the vicinity of Siirt. The live storage at the normal storage level will be 7'460 Mm^3 (Table 2-2).

For the construction period, 3 diversion tunnels below the left abutment of the dam, with a capacity of 1'200 m^3/s each, will be necessary for the river to bypass the construction site.

The 1'200 MW powerplant will include 6 Francis turbine units of 200 MW. Three 420 m long penstocks will be constructed in the dam right abutment. The single phase generator transformers will be connected via 380 kV lines to the switchyard located at a distance of 1,5 km on the right bank. A 160 km, 3 circuits 380 kV line, will be built between Ilisu and the Diyarbakir main substation where it will be integrated in the existing Turkish grid. The impacts of this line project are not included in the scope of this EIAR. When considering the water needs of the upstream projects already in operation, under construction or planned, the average annual energy production will amount to 3'618 GWh.

The spillway is designed for a maximum discharge of 18'000 m^3/s at maximum flood level 526.8. The sill of the spillway structure will be 15 m below the reservoir normal storage level of 525 m. It will be controlled by 8 radial gates, each 16 m wide, designed to provide flood releases avoiding sudden changes which could cause damages downstream. For floods not exceeding 12'500 m^3/s (corresponding to the 1'000 year flood), the reservoir level is unlikely to rise above level 525.

The layout of the dam and appurtenant structures is given in Appendix 8 while the reservoir extension is shown in Appendices 1, 3, 4, 5, 6, 9, 14, 15, 16, 17, 18 and 19 at different scales.

The rock foundation at the damsite is marly limestone. Significant deformations in the dam body during construction or afterward are not expected. The reservoir will be filled gradually to permit the foundations as well as the dam body to adapt to the new loading conditions. This will contribute to minimize these deformations.

According to the seismic evaluation in the Final Design, earthquakes with a magnitude of 6 (Richter scale) are possible at the damsite. Various seismic studies were carried out and indicated possible instantaneous peak accelerations at the damsite between 0,23 and 0,9 g.

All seismic designs were carried out using a pseudo-static approach. When dynamic forces are simulated by equivalent pseudo-static forces, instantaneous peaks need to be modified to assign longer duration design values. For the pseudo-static design approach, it was concluded that a value of about half the isolated peak acceleration should be used and 2 basic design criteria were adopted:

A design earthquake (DE) of 0,2 g which should not cause significant damages or problems of stability to structures relating to dam safety.

A maximum credible earthquake (MCE) of 0,4 g which could generate stresses above design assumptions and which might cause damage although the structures would remain stable and, in the case of the dam, would still be capable of retaining water at the normal storage level.

These assumptions appear appropriate. However, based on the additional knowledge which could be compiled in this field during the recent years, an updated seismic hazard assessment and dynamic analysis should be carried out before construction for the dam, powerplant and main control building to ascertain that all required measures for securing the safety of the structures have been properly taken into account in the Final Design.

2.4.2 Project selection and state of planning

Investigations to evaluate the hydro potential of the Tigris River below elevation 550 began in 1954 along a 53 km long section of the river. Based on the results of these studies, DSI issued in 1971 the "Tigris River Pre-Investigation Report" dealing with the 10 alternative damsite identified.

The technical and economical evaluation of these damsites was performed in the "Engineering Geology Report" issued by EIE in 1975.

In 1980, EIE appointed an international consultant consortium, composed of Binnie & Partners, James Williamson & Partners, Kennedy & Donkin, Coba and Gizbili Consulting Engineers, with the performance of a Feasibility Study and the preparation of the Final Design for the Ilisu Project.

These studies were completed in 1982 and concluded that Ilisu had to be implemented and that the construction of the Cizre Project had to be considered to better regulate the discharges downstream of Ilisu.

Ilisu was then included in the construction program in 1998.

Out of the 10 dam axis identified in 1971, 9 were located in the topographically more favorable narrow sections of the valley and one, Ilisu, in a substantially wider valley section.

The following Table summarizes these studies from upstream to downstream and explains briefly why the Ilisu site had finally to be selected:

Site name	Distance from Ilisu [km]	Talweg elev. Dam height/ Crest length [m]	Inves- tigation boreholes	Geological situation
Rezuk I	31 U/S	430 90 560	2	Midyat Formation, highly karstified, risks of seepage requiring excessive grouting works
Rezuk III	29 U/S	420 100 550	0	Midyat Formation, karstified over a depth of around 250 m and covering the Gercüs Formation, provision of an enormous and problematic grout curtain needed
Rezuk II	28 U/S	420 100 520	15	Midyat limestone closely underlain by the Gercüs Formation with gypsum and anhydrite layers
Pireder	16 U/S	415 105 580	0	Midyat Formation, karstified and chalky, similar to the limestone encountered at Rezuk III, risks of leakage around the Pireder creek
Dermah	14 U/S	413 107 465	18	Midyat Formation with solution cavities and caverns overlying the gypsiferous Gercüs Formation at a depth of 150 m, the latter being also exposed in the reservoir area 1 km U/S. Occurrence of karstic springs with significant discharges 50÷60 m above the talweg
Ilisu	0.0	400 120 1530	106	Germav Formation (Section 3.1.7.1)

Baniga	3 D/S	395 125 300	0	Same situation as at Dermah with karstic springs in the Midyat Formation 50÷60 m above the talweg and exposure of the Gercüs Formation in the reservoir 1 km U/S
Dilan	10 D/S	390 130 450	0	Same situation as at Baniga but with location of the Gercüs Formation at a depth up to 200 m and a groundwater table notably lower than the talweg and requiring extensive grouting works at the damsite
Hitme	20 D/S	380 140 450	0	Here too, the Midyat Formation presents numerous solution cavities attesting of a developed karstification endangering the reservoir watertightness at the damsite unless an expensive grout curtain is implemented
Bafi	29 D/S	370 150 500	0	Same conditions as at Hitme but with the Gercüs Formation even lower down at about 300 m depth

All these sites have been the object of a detailed geological mapping, the most promising ones beside Ilisu, i.e. Rezuk II and Dermah, having even been investigated with drillholes in order to better clarify the geological conditions prevailing in the dam abutments and foundations, especially the watertightness which, in such limestone formations, is of uttermost importance for the technical viability of the project. The developed karsticity of the Midyat Formation as well as the presence of gyps and anhydrite in the Gercüs Formation led to eliminate all the sites presenting favorable topographical features. Finally, all efforts were therefore concentrated on the Ilisu site in spite of the quite large embankment volume required because this site appeared to be less problematical with regard to watertightness and extension of the grouting works.

As the discharges of the Tigris River and its tributaries exhibit large seasonal and inter-annual variations (a factor of 10 between the average driest month and the average wettest month), the Project includes a relatively large reservoir, the normal storage level of which was finally set some meters higher than during the preliminary studies. It must be noted here that this Final Design setting was not changing the conclusions drawn during the preliminary studies, on the contrary because the difficulties and costs of the watertightening works increasing rapidly with the dam height.

The Project is based on the optimization of the dam height and installed power capacity according to a cost-benefit analysis. This was a complex process involving modeling the

operation over a long period of historical river flow data and comparing the costs and benefits for various different configurations. The choice of the installed capacity of 1'200 MW and the dam height (normal storage level 525) was made by Temel in their Feasibility Report [163], [164], [165].

These choices were reviewed and ratified during the Final Design process. The design has been studied in detail during the 70's and 80's so that the Final Design has been approved by the Turkish authorities in 1982 after the performance of extended field investigation campaigns including drillholes, geophysical explorations, adits and plate bearing tests, laboratory and hydraulic model tests.

This setting improves the seasonal and inter-annual water regulation with the objective of an adequate energy production throughout the year and particularly during dry periods. As a consequence, the water releases from the powerplant will be larger during the dry season (summer, autumn, beginning of winter) than it is today, but less during the spring flood season. Thus the risks of both floods and droughts for downstream riparian people will be attenuated, and a more consistent and higher river flow during the critical crop growing season will prevail. These features will favorably influence the discharge pattern of the river downstream.

The consequences of a reduction of the dam crest level by 30 m were also investigated (normal storage level at 495 instead of 525) [273]. The study led to the conclusion that such a reduction would result in an excessive reduction of the energy production:

Feature	Normal storage level	
	525	495
Installed capacity	1'200 MW	600 MW
Firm energy production	100 %	52 %
Total energy production (Firm + secondary)	100 %	64 %

In spite of the scheduled commissioning of large plants like Karakaya and Atatürk devoted to a great extent to the production of peak energy, the problem of satisfying the continuously increasing demand resulting from the fast urbanization and industrialization of the country was already acute when the Turkish authorities decided to proceed to the Final Design studies for the Project at the end of the seventies.

This explains why an installed capacity of 1'200 MW with 6 units capable of discharging simultaneously 1'266 m^3/s was decided, while the average yearly discharge of the Tigris River

at the damsite amounts to only 503 m³/s (last evaluation update). The load factor (also called utilization factor) of the plant resulting from this setting decided at the beginning of the eighties amounts therefore to only 40%, while it was 48% for Atatürk (upgraded in 1977 on the basis of the last forecasts) and 52% for Karakaya (1972). This clearly reflects the Turkish energy policy trend to grant more attention to the peak energy production.

It was intended therewith to meet the demand during few hours in the morning and from late afternoon to about 10 p.m. which are the times during which shortage is acute. In 1996, it appeared indispensable to implement the Project the soonest possible for securing the continuing rapid and important increase of the hydropower installed capacity.

2.4.3 Alternative hydro projects along the river section between Bismil and Ilisu

Studies performed in many countries around the world show as a general trend that series of smaller hydropower stations with lower heads and smaller reservoirs are less economical than a single high dam with a large reservoir taking advantage of the maximum head available. For example, the review of more than 100 projects in Thailand within the framework of an energy master plan confirmed the general trend that the construction costs per unit installed capacity decrease with the increasing size of the powerplants. The results of this study show that the reduction of the installed capacity by a factor 10 roughly doubles the investment required.

The reasons for a single large plant being more economical than a series of smaller plants are:

The regulation capacity of a system of several smaller reservoirs is more limited than that of a large plant which achieves a better controlled regulation of the downstream river discharges. In addition, a large reservoir can store large river flows during the wet season. Therefore, the latter is more flexible to cover the power and energy needs, especially during the dry season and is more suitable to produce high valuable peak energy. Compared with this, a system of smaller power plants with little storage capacities has at the limit to be run as a chain of run-off river powerplants which can only produce energy according to the momentary flow of the river.

In addition, a system of smaller powerplants produces less energy than one large plant because only a part of the full head of the system is available to the run-off from intermediate watersheds. Also, the operation ranges of the series of powerplants penalize the available head developed in a single comparable large powerplant.

The flood routing is significantly more efficient in large reservoirs because the attenuation of the flood peaks is significantly larger than in reservoirs with a reduced surface and/or storage capacity in which this attenuation effect can even become negligible. The consequence is that for a small reservoir, either the spillway capacity must be increased, which results in additional costs, or the minimum operation level must be lowered, which negatively influences the energy production, the value of this energy and the environmental impacts. In any case, the flood protection downstream is better secured with a large storage plant than with a succession of small reservoirs.

A large part of the costs is related to the construction of the dams. Therefore, the ratio "dam volume / installed capacity" provides a kind of indicator for the intrinsic value of a hydropower project. In general, this ratio is larger, i.e. less favorable for small plants. This indicator generally gives priority to a single large dam in comparison to several smaller ones totaling the same installed capacity.

Foundation conditions, powerhouse and flood discharge facilities have an important influence on the construction costs too because for each dam in a chain of successive smaller reservoirs on the same river or in the same basin, a river diversion during construction, a spillway, a bottom outlet, and other appurtenant structures are needed at each site. This leads to total costs which may largely exceed the investments required for a single large dam only.

The influence of the reservoir size, of the dam embankment volume and of the energy production can be roughly evaluated in a purely theoretical comparative analysis between the Final Design and the combination of a "Low Ilisu" alternative (Same damsite as for the Project, normal storage level lowered at 555) with one to 3 hypothetical complementary damsites considering the following normal storage levels:

Hypothetical damsite	Normal storage level	Location
"Hasankeyf"	525	Tigris River, about. 11 km upstream of Hasankeyf
"Garzan"	525	Garzan River, about. 6 km upstream of the confluence with the Tigris
"Botan"	525	Botan River, about 5 km upstream of the confluence with the Tigris

The tails of the corresponding hypothetical reservoirs in the upper Tigris valley and the valleys of the tributaries would therewith flood the same areas as with the normal storage level at 525 of the Final Design, but it would be possible to prevent the flooding of Hasankeyf.

Following cases have been considered for this comparisons:

Case	Dams
1	Ilisu Final Design (reference case)
2	"Low Ilisu" + "Hasankeyf"
3	"Low Ilisu" + "Hasankeyf" + "Botan"
4	"Low Ilisu" + "Hasankeyf" + "Garzan" + "Botan"

The reservoir operation ranges of the hypothetical "Hasankeyf", "Garzan" and "Botan" reservoirs, including that of the "Low Ilisu" storage were arbitrarily assumed to be 10 m each, as the heads would be about half that of the Final Design Project. The results of the comparisons are shown in the following Table:

Cumulated main technical features	Case 1	Case 2	Case 3	Case 4
Reservoir active storage volumes [Mm^3]	3'700* (100%)	800 (22%)	1'300 (35%)	1'600 (43%)
Reservoir areas [km^2]	300 (100%)	98 (33%)	153 (51%)	193 (64%)
Dam volumes [Mm^3]	44 (100%)	12 (27%)	28 (64%)	35 (80%)
Energy production potential** [GWh]	100%	62%	82%	87%

* Average with an operation range of 15 m
**The energy production potential is simply proportional to the product of the mean annual river flow with the average gross hydraulic head. It is a rough indicator for the annual energy production and not taking into account the availability of the reservoir storage volume, friction losses along the waterways, efficiencies of turbines, generators and transformers as well as occurrence of spills and does not represent therefore the actual energy production in kWh.

The results can be summarized as follows:

The cumulative areas of the reservoirs would be substantially reduced.

As a consequence of the wide valley opening at the Ilisu damsite, the cumulated volumes of the hypothetical dams would remain inferior by only 20% in Case 4.

The total energy produced by the hypothetical system of dams would be theoretically reduced between 13 and 38%. In fact this reduction would be significantly larger, not only because the spills would be much more frequent than with the Project, due to the smaller cumulated active storage volumes available, but also because of the simplified assumptions made for roughly appraising the available potential.

The cumulated active storages of the hypothetical dams being significantly smaller than for the Project, it would not be possible to store all large river flows during the wet season. The leveling effect on the river flow and the energy production during the dry season would therefore be noticeably reduced.

It should be noticed that the comparison of the dam volumes represents only an indicator for the overall costs because it does not include the numerous additional investments required for a system of several plants needing each a river diversion works, a bottom outlet, a spillway, a powerhouse, additional operation personnel and extra transmission lines, as well as expensive foundation treatments, the latter leading often to condemn a damsite appearing at first look to be topographically favorable.

The results of this conservative comparison demonstrate that the Final Design Project, despite its drawbacks related to the cultural heritage, is by far superior to other alternatives for the following main reasons:

Less frequent operation of the spillway, which means more efficient use of the available inflows.

Better inter-annual compensation of the inflows securing larger discharges downstream during dry or a succession of dry years.

Optimization of the energy production.

It must also be underlined that the above results fully neglect any aspect of the technical and economical feasibility of the hypothetical alternative damsites assumed, so that it can undoubtedly be concluded that the Project as defined by the Final Design permits to optimally achieve the development of this river section.

2.5   PROJECT IMPLEMENTATION

2.5.1 Construction schedule

The construction of the Project is scheduled over a period of 7 1/2 years approximately (including commissioning). The construction program considers a period of 2 years for the

reservoir impounding and includes the improvement and construction of access roads. A bridge across the Tigris River will also be built downstream of the dam. Installation of temporary power supply and telecommunication for construction purposes are also included in the construction schedule (Appendix 23).

2.5.2 Construction team

The construction team will include engineers, technicians, skilled, semi-skilled and unskilled labor, local and expatriate foremen, surveyors, truck drivers and machine operators as well as administrative personnel. At the construction peak period, the total number of the persons being at the same time on the construction site should not exceed 5'000. The Contractor will have to provide sufficient facilities for his construction workers and staff as well as for their residential family members. He must install and maintain the required drinking and waste water systems in accordance with the Turkish Regulations.

2.5.3 Excavation and embankment works

Excavations will be required for roadwork, dam and cofferdam foundations, borrow areas, rock quarries, removal of the cofferdams, as well as tunneling works for river diversion and penstocks. These excavations will be mostly performed in alluvium, slope wash, alluvial terrace deposits, marly limestone and limestone. Because of the lithologic characteristics of the formations, the excavations will generally be carried out with bulldozers and excavators. Parts of these excavations will require drilling and blasting.

The fill material for the dam embankment will be borrowed nearby in the Tigris valley upstream of the damsite or, when convenient, directly from excavation works required for the dam and appurtenant structures. The Contractor shall execute investigations to determine the thickness of the formations and select the working methods convenient to obtain the required grain size distribution. All suitable excavated material should be used directly as fill or temporarily stockpiled before it can be used for its final destination. The Contractor shall ensure that no excavated material will be disposed outside of the areas allocated for this purpose.

2.5.4 Accesses and service roads on site

Construction of roads to a modified highway standard "2B" from Findik to the site is necessary together with a by-pass around Dargeçit. These roads will be linked to the bridge to be constructed on the Tigris River downstream of the dam. Improvement is furthermore required for the Dargeçit-Midyat junction road.

Service roads, access tracks to the borrow areas and quarries, accesses roads to the camp and to the DSI village, storage, laydown and parking areas will be required during the construction stage. These facilities will be maintained by the Contractor during the whole construction period and those required for the operation stage will be handed over to DSI after commissioning.

Ilisu Dam and HEPP
Environmental Impact Assessment Report

Tables for Section 2

Ilisu Engineering Group
April 2001

Projects and units	Installed capacity [MW]	Energy production [GWh]	Irrigated area [ha]	Project status
Euphrates Basin, GAP Projects				
1 Karakaya Project	**1'800**	**7'354**	**-**	
Karakaya Dam and HEPP	1'800	7'354	-	OP
2 Lower Firat Project	**2'450**	**9'024**	**702'595**	
Atatürk Dam and HEPP	2'400	8'900	-	OP
Sanliurfa HEPP	50	124	-	CO
Sanliurfa Tunnel and Irrigation	-	-	470'135	CO + OP
Sanliurfa-Harran Irrigation	-	-	152'353	CO + OP
Mardin-Ceylanpinar Gravity Irrigation	-	-	94'929	PL + CO
Mardin-Ceylanpinar Pumping Irrigation	-	-	118'264	PL
Groundwater Irrigation	-	-	104'589	PL
Siverek-Hilvan Pumping Irrigation	-	-	185'092	PL
Bozova Pumping Irrigation	-	-	47'368	PL + FD
3 Sinir Firat Project	**861**	**3'168**	**-**	
Birecik Dam and HEPP	672	2'516	-	OP
Karkamis Dam and HEPP	189	652	-	OP
4 Suruç-Yaylak Project	**-**	**-**	**114'826**	
Yaylak Plain Irrigation	-	-	20'012	PR
Suruç Plain Irrigation	-	-	94'814	PL + PR
5 Adiyaman-Kahta Project	**195**	**509**	**77'824**	
Çamgazi Dam and Irrigation	-	-	7'430	CO
Gömikan Dam and Irrigation	-	-	6'868	MP
Koçali Dam, HEPP and Irrigation	40	120	21'605	MP
Sirimtas Dam and HEPP	28	87	-	MP
Fatopasa HEPP	22	47	-	MP
Büyükçay Dam, HEPP and Irrigation	30	84	12'322	MP
Kahta Dam and HEPP	75	171	-	MP
Pumping from Atatürk Dam Reservoir		--	29'599	PL + CO
6 Adiyaman-Göksu-Araban	**7**	**43**	**71'598**	
Çataltepe Dam	-	-	-	PL
Gölbasi, Abbassiye, Besni-Keysun, Araban, Kizilin, Yavuzeli, Incesu, Pazarcik Irrigation	-	-	71'598	RE
Erkenek HEPP	7	43	-	RE

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7	**Gaziantep Project**	**-**	**-**	**142'664**	
	Hancagiz Dam and Irrigation	-	-	6'945	OP
	Kayacik Dam and Irrigation	-	-	20'000	CO
	Kemlin Dam and Irrigation	-	-	3'088	PL
	Bayramli Regulation and Irrigation	-	-	4'730	CO + PL
	Belkis Nizip Pumping Irrigation	-	-	11'925	CO
	Pumping from Birecik Dam Reservoir	-	-	95'976	PL

Total Euphrates Basin, GAP Projects	**5'313**	**20'098**	**1'109'507**

Euphrates Basin, Miscellaneous Projects				
Nusaybin Irrigation	-	-	7'500	OP
Çagçag HEPP	14	42	-	OP
Akçakale Groundwater Irrigation	-	-	15'000	OP
Ceylanpinar Groundwater Irrigation	-	-	27'000	OP
Hacihidir Project	-	-	2'080	OP
Dumluca Project	-	-	1'860	OP
Seve Dam and Irrigation	-	-	1'400	PR
Besni Dam and Irrigation	-	-	2'820	PL
Ardil Dam and Irrigation	-	-	3'535	PL
Nusaybin Çagçag 2nd Stage Project	-	-	9'170	PL
Total Euphrates Basin, Miscellaneous	**14**	**42**	**70'365**	

	Tigris Basin, GAP Projects				
8	**Kralkizi-Dicle Project**	**204**	**444**	**130'159**	
	Kralkizi Dam and HEPP	94	146	-	OP
	Dicle Dam and HEPP	110	298	-	OP
	Dicle Right Bank Gravity Irrigation	-	-	54'279	PR + CO
	Dicle Right Bank Pumping Irrigation (P2 and P5)	-	-	23'085	CO
	Dicle Right Bank Pumping Irrigation (P6)	-	-	7'845	PR
	Dicle Right Bank Pumping Irrigation (P3 and P4)	-	-	44'950	PR
9	**Batman Project**	**198**	**483**	**37'351**	
	Batman Dam and HEPP	198	483	-	IM
	Batman Left Bank Irrigation	-	-	18'758	CO
	Batman Right Bank Gravity Irrigation	-	-	18'593	CO
10	**Batman-Silvan Project**	**240**	**964**	**257'000**	
	Silvan Dam and HEPP	150	623	-	MP
	Kayser Dam and HEPP	90	341	-	MP
	Dicle Left Bank Gravity Irrigation	-	-	200'000	MP
	Dicle Left Bank Pumping Irrigation	-	-	57'000	MP
11	**Garzan Project**	**90**	**315**	**60'000**	
	Garzan Dam and HEPP	90	315	-	RE
	Garzan-Kozluk Irrigation	-	-	60'000	RE

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12 Ilisu Project	**1'200**	**3'833**	**-**	
Ilisu Dam and HEPP	1'200	3'833	-	PR
13 Cizre Project	**240**	**1'208**	**121'000**	
Cizre Dam and HEPP	240	1'208	-	PR
Nusaybin-Cizre-Idil Irrigation (Downstream of Cizre)	-	-	89'000	RE
Silopi Plain Irrigation (Downstream of Cizre)	-	-	32'000	RE

Total Tigris Basin, GAP projects	**2'172**	**7'247**	**605'510**	

Tigris Basin, Miscellaneous Projects				
Ergani Dam and Irrigation	-	-	1'861	PL
Devegeçidi Dam and Irrigation	-	-	7'500	OP
Dilaver Dam and Çinar-Dilaver Irrigation	-	-	3'575	PL
Göksu Dam and Çinar-Göksu Irrigation	-	-	3'582	OP
Silvan Irrigation, Stages I and II	-	-	8'790	OP
Garzan Kozluk Irrigation	-	-	3'700	OP
Nerdus Irrigation (Downstream of Cizre)	-	-	2'740	OP
Total Tigris Basin, Miscellaneous	**0**	**0**	**31'748**	

CO: Construction   IM: Impounding   OP: In operation   PR: In program

FD: Final Design   MP: Master Plan   PL: Planning   RE: Reconnaissance

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ILISU DAM AND HEPP
Table 2 - 2
Salient features of the Ilisu Dam and HEPP Project

Item	Unit	Data-Feature
Hydrology		
River	-	Tigris
Main tributaries (left bank)	-	Batman, Garzan, Resan, Kezer, Botan, Zarova
Catchment area	km^2	35'517
Average annual inflow / Discharge	Mio m^3 / m^3/s	15'450 / 490
Average elevation of catchment area	m	1'300
Minimum / maximum temperature at site	^{0}C	-9 / 48
Reservoir		
Normal storage level / Minimum operation level	m	525 / 485
Talweg level	m	400
Inactive / Active / Total storage	Mio m^3	2'950 / 7'460 / 10'410
Reservoir surface / length	km^2 / km	313 / 136 +108
Dam		
Dam type	-	Rockfill with central core
Crest elevation / Dam height	m	530 / 135
Crest length / width	m	1'820 / 15
Dam foot width	m	610
Dam volume	Mio m^3	43.8
Diversion facilities		
Type of diversion tunnels	-	Lined circular
Number / Inside dimensions / Length	m	3 / 12.0 / 897 ÷ 1'099
Capacity	m^3/s	3'600
Inlet / outlet elevation	m	400 / 399
Crest elevation of U/S / D/S cofferdam	m	420.60 / 412.00
Spillway		
Type	-	Controlled overflow
Number / Type of gates	-	8 / Radial gates
Number of chutes / Energy dissipation	-	4 / Plunge pool
Ogee crest elevation	m	510
Discharge	m^3/s	18'000
Power Intake-Penstocks		
Number / Length	m	3 / 407
Diameter	m	ø 11.0÷9.00
Type of control	-	Inclined sliding gate
Dimensions of gates	m	13.25 x 6.85

TABLE 2 - 2   PAGE 1/2

ILISU DAM AND HEPP
Table 2 - 2
Salient features of the Ilisu Dam and HEPP Project (Continued)

Item	Unit	Data-Feature
Powerhouse		
Type	-	Outdoor at dam foot
TURBINES		
Inlet gate number / Type / Diameter	- / mm	6 / Butterfly / ø 5'600
Number of units / Type	-	6 / Francis vertical
Turbine axis elevation / Gross head / Net head	m	400 / 122.6 / 110
Rated discharge / Speed	m^3/s / rpm	211 / 136.4
Installed capacity	MW	6 x 200
Firm / Secondary / Total energy	GWh	2'459 / 1'374 / 3'833
Load factor	-	36.5
GENERATORS		
Type / Exciter system	-	Synchronous/Static
Voltage / Frequency	kV / Hz	15 / 50
Maximum continuous rating	MVA	220
TRANSFORMERS		
Number / Type	-	6 x 3 / Single phase
Capacity	MVA	3 x 73.3
Voltage ratio	kV / kV	15 / 38
		0
TAILRACE CHANNEL		
Tailwater level minimum / maximum	m	402.4 / 405.3
Tailwater level at spillway design discharge	m	420.5

Item	Unit	Data-Feature
Switchyard		
Type	-	Conventional outdoor
Number / Voltage of incoming lines	kV	6 / 380
Number / Voltage of outgoing lines	kV	2 / 380
Auto transformer ratio	kV / kV	380 / 154

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ILISU DAM AND HEPP
Table 2 - 3
Salient features of the Cizre Dam and HEPP Project

Item	Unit	Data-Feature
Hydrology		
River	-	Tigris (Dicle)
Main tributaries (left bank)	-	Batman, Garzan, Resan, Kezer, Botan, Zarova
Catchment area	km^2	38'295
Average annual inflow / Discharge	Mio m^3 / m^3/s	16'600 / 526
Average elevation of catchment area	m	
Minimum / maximum temperature at site	^{0}C	-9 / 48
Reservoir		
Normal storage level / Minimum operation level	m	404.4 - 392
Talweg level	m	363
Inactive / Active / Total storage	Mio m^3	152 / 208 / 360
Reservoir surface / length	km^2 / km	21 / 40
Dam		
Dam type	-	Earthfill with central core
Crest elevation / Dam height	m	409 / 46
Crest length / width	m	740 / 15
Dam foot width	m	190
Dam volume	Mio m^3	3.3
Diversion facilities		
Type of diversion tunnels	-	Rectangular culverts
Number / Inside dimensions / Length	m	5 / 10 x 9 / 200
Capacity	m^3/s	3'850
Inlet / outlet elevation	m	359 / 358
Crest elevation of U/S / D/S cofferdam	m	382 / 375
Spillway		
Type	-	Controlled overflow
Number / Type of gates	-	8 / Tainter
Number of chutes / Energy dissipation	-	/ Stilling basin
Ogee crest elevation	m	389.4
Discharge	m^3/s	18'700
Power Intake-Penstocks		
Number / Length	m	3 / 157
Diameter	m	7.45
Type of control	-	Sliding gate
Dimensions of gates	m	12 x 5

TABLE 2 - 3   PAGE 1/2

ILISU DAM AND HEPP
Table 2 - 3
Salient features of the Cizre Dam and HEPP Project (Continued)

Item	Unit	Data-Feature
Powerhouse		
Type	-	Open air
TURBINES		
Inlet gate number / Type / Diameter	- / mm	3 / /
Number of units / Type	-	3 / Francis vertical
Turbine axis elevation / Gross head / Net head	m	365 / 36 / 34
Rated discharge / Speed	m³/s / rpm	/ 180
Installed capacity	MW	3 x 80
Firm / Secondary / Total energy	GWh	947 / 261 / 1'208
Load factor		0.57
GENERATORS		
Type / Exciter system	-	Vertical shaft / Synchro
Voltage / Frequency	kV / Hz	15 / 50
Maximum continuous rating	MVA	90
TRANSFORMERS		
Number / Type	-	3 / Triphase
Capacity	MVA	90
Voltage ratio	kV / kV	15 / 380
TAILRACE CHANNEL		
Tailwater level minimum / maximum	m	368.8 / 380
Tailwater level at spillway design discharge	m	385

Item	Unit	Data-Feature
Switchyard		
Type	-	Conventional outdoor
Number / Voltage of incoming lines	kV	3 / 380
Number / Voltage of outgoing lines	kV	2 / 380
Auto transformer ratio	kV / kV	380 / 154

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ILISU DAM AND HEPP
Table 2 - 4
Salient features of the Ergani, Kralkizi and Dicle Dam Projects

Plant Item	Unit	Ergani Data-Feature	Kralkizi Data-Feature	Dicle Data-Feature
Hydrology				
River	-	Kalhane (Furtakse tribut)	Tigris	Tigris
Catchment area	km^2	44	1'300	3'216
Average annual inflow / Discharge	Mio m^3 / m^3/s	19 / 0.6	761 / 24.1	1'924 / 61
Average elevation of catchment area	m		1'100	1'000
Minimum / maximum temperature at site	^{0}C		-24 / 46	-24 / 46
Reservoir				
Normal storage / Minimum operation level	m	912 / 883	815.75 / 762	710 / 702.5
Talweg level	m	872	707	640
Inactive / Active / Total storage	Mio m^3	1 / 14 / 15	208 / 1'711 / 1'919	340 / 255 / 595
Reservoir surface / length	km^2 / km	1 /	58 / 26	24 / 20
Dam				
Dam type	-	Rockfill	Rockfill with central core	Rockfill
Crest elevation / Dam height	m	915 / 43	819 / 113	718 / 75
Crest length / width	m		1'030 / 12	307 / 10
Dam foot width	m		550	328
Dam volume	Mio m^3	0.5	14.5	3.1
Diversion facilities				
Type of diversion tunnels	-	Lined circular	Lined circular	Lined circular
Number / Inside dimensions / Length	m	1 / / 325	2 / 6.0 / 534÷585	2 / 7.6 / 302÷444
Capacity	m^3/s	40	1'300	1'500
Inlet / outlet elevation	m		709 / 706	646 / 644
Crest elevation of U/S / D/S cofferdam	m		745 / 713	672 / 655
Spillway				
Type	-	Free overflow	Controlled overflow	Controlled overflow
Number / Type of gates	-		4 / Tainter	4 / Tainter
Number of chutes / Energy dissipation	-		1 / Flip bucket	1 / Flip bucket
Ogee crest elevation	m	912	802	701
Discharge	m^3/s	110	2'300	5'000

TABLE 2 - 4   PAGE 1/2

ILISU DAM AND HEPP
Table 2 - 4
Salient features of the Ergani, Kralkizi and Dicle Dam Projects (Continued)

Power Intake-Penstocks				
Number / Length	m	-	2 / 380÷395	1 / 455
Diameter	m	-	6.0÷5.5	8.5 ÷ 7.5
Type of control	-	-	Sliding gates	Sliding gates
Dimensions of gates	m	-	6 x 9	8.5 x 10.5

Powerhouse				
Type	-	-	Open air	Open air
TURBINES				
Inlet gate number /Type / Diameter	- / mm	-	2 / Butterfly / 3'200	2 / Butterfly / 4'000
Number of units / Type	-	-	2 / Francis	2 / Francis
Turbine axis elevation / Gross head / Net head	m	-	703.75 / 71 / 68	640.8 / 67 / 65
Rated discharge / Speed	m^3/s / rpm	-	81 / 250	114 / 187.5
Installed capacity	MW	-	2 x 47	2 x 55
Firm / secondary / Total energy	GWh	-	111 / 35 / 146	220 / 70 / 298
Load factor	-	-	0.18	0.31
GENERATORS				
Type / Exciter system	-	-	Vertical shaft / Synchro	Vertical shaft / Synchro
Voltage / Frequency	kV / Hz	-	15 / 50	15 / 50
Maximum continuous rating	MVA	-	50	60
TRANSFORMERS				
Number / Type	-	-	3 / Triphase	3 / Triphase
Capacity	MVA	-	33	41
Voltage ratio	kV / kV	-	15 / 154	15 / 154
TAILRACE CHANNEL				
Tailwater level minimum / maximum	m	-	708 / 715	641 / 642
Tailwater level at spillway design discharge	m	-	720	

Switchyard				
Type	-	-		
Number / Voltage of incoming lines	kV	-	3 / 154	3 / 154
Number / Voltage of outgoing lines	kV	-	2 / 154	2 / 154
Auto transformer ratio	kV / kV	-		

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ILISU DAM AND HEPP
Table 2 - 5
Salient features of the Devegeçidi, Dilaver and Göksu Dam Projects

Plant		Devegeçidi	Dilaver	Göksu
Item	**Unit**	**Data-Feature**	**Data-Feature**	**Data-Feature**
Hydrology				
River	-	Furtaksa (Tribu. TigrisR/B)	Kuruçay(Tigris trib. R/B)	Göksu (Tribut. Tigris R/B)
Catchment area	km^2	1'578	648	672
Average annual inflow / Discharge	Mio m^3/ m^3/s	210 / 6.7	79 / 2.5	86 / 2.7
Average elevation of catchment area	m	850		
Minimum / maximum temperature at site	^{0}C	-23 / 45		
Reservoir				
Normal storage / Minimum operation level	m	757 / 739.5	809 / 795	700 / 682
Talweg level	m	726	771	657
Inactive / Active / Total storage	Mio m^3	7 / 212 / 219	8 / 68 / 76	12 / 44 / 56
Reservoir surface / length	km^2 / km	30 / 13		4.2 /
Dam				
Dam type	-	Rockfill	Rockfill	Rockfill
Crest elevation / Dam height	m	759 / 33	815 / 44	702 / 148
Crest length / width	m	6'690 / 8	740 / 10	674 / 10
Dam foot width	m	135		226
Dam volume	Mio m^3	3.2	1.9	1.9
Diversion facilities				
Type of diversion tunnels	-	Lined circular	Lined circular	Lined circular
Number / Inside dimensions / Length	m	1 / 8 / 580	1 / 6.5 / 300	1 / 5 / 400
Capacity	m^3/s	429	540	162
Inlet / outlet elevation	m	735 / 734		658 / 656
Crest elevation of U/S / D/S cofferdam	m	743 /		673 /
Spillway				
Type	-	Controlled overflow	Free overflow	Free overflow
Number / Type of gates	-	6 / Tainter		
Number of chutes / Energy dissipation	-			
Ogee crest elevation	m	748.5	809	700
Discharge	m^3/s	2'600	2'300	2'150

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ILISU DAM AND HEPP
Table 2 - 5
Salient features of the Devegeçidi, Dilaver and Göksu Dam Projects (Continued)

Power Intake-Penstocks				
Number / Length	m	-	-	-
Diameter	m	-	-	-
Type of control		-	-	-
Dimensions of gates	m	-	-	-

Powerhouse				
Type	-	-	-	-
				-
TURBINES				
Inlet gate number /Type / Diameter	- / mm	-	-	-
Number of units / Type	-	-	-	-
Turbine axis elevation / Gross head / Net head	m	-	-	-
Rated discharge / Speed	m³/s / rpm	-	-	-
Installed capacity	MW	-	-	-
Firm / secondary / Total energy	GWh	-	-	-
Load factor	-	-	-	
GENERATORS				
Type / Exciter system	-	-	-	-
Voltage / Frequency	kV / Hz	-	-	-
Maximum continuous rating	MVA	-	-	-
TRANSFORMERS				
Number / Type	-	-	-	-
Capacity	MVA	-	-	-
Voltage ratio	kV / kV	-	-	-
TAILRACE CHANNEL				
Tailwater level minimum / maximum	m	-	-	-
Tailwater level at spillway design discharge	m	-	-	-

Switchyard				
Type	-	-	-	-
Number / Voltage of incoming lines	kV	-	-	-
Number / Voltage of outgoing lines	kV	-	-	-
Auto transformer ratio	kV / kV	-	-	-

TABLE 2 - 5   PAGE 2/2

ILISU DAM AND HEPP
Table 2 - 6
Salient features of the Silvan, Kayser and Batman Dam Projects

Plant		Silvan	Kayser	Batman
Item	Unit	Data-Feature	Data-Feature	Data-Feature
Hydrology				
River	-	Batman	Zori (Batman tributary)	Batman
Catchment area	km^2	2'305	789	4'105
Average annual inflow / Discharge	Mio m^3/ m^3/s	1'856 / 58.9	1'433 / 45.4	4'198 / 133.1
Average elevation of catchment area	m			900
Minimum / maximum temperature at site	^{0}C	-24 / 46	-24 / 46	-24 / 46
Reservoir				
Normal storage / Minimum operation level	m	820 / 790		665 / 645
Talweg level	m	660	700	596
Inactive / Active / Total storage	Mio m^3	2'662 / 4'138 / 6'800	492 / 527 / 1'019	437 / 738 / 1'175
Reservoir surface / length	km^2/ km	181 / 35	22 / 10	49 / 15
Dam				
Dam type	-	Rockfill	Rockfill	Earth-rockfill
Crest elevation / Dam height	m	824.5 / 166.5	833.5 / 134	670 / 74
Crest length / width	m	446 / 15	256 / 12	510 / 12
Dam foot width	m	690	570	300
Dam volume	Mio m^3	13	4.8	4
Diversion facilities				
Type of diversion tunnels	-	Lined circular	Lined circular	Lined circular
Number / Inside dimensions / Length	m	1 / 12 / 1'100	1 / 10 / 1'200	1 / 12 / 580
Capacity	m^3/s	/ / 2'010	1'000	1'900
Inlet / outlet elevation	m			597 / 594
Crest elevation of U/S / D/S cofferdam	m	679.5 / 670. 5	716 / 710	630 / 610
Spillway				
Type	-	Controlled overflow	Controlled overflow	Controlled overflow
Number / Type of gates	-	4 / Tainter	2 / Tainter	4 / Tainter
Number of chutes / Energy dissipation	-			
Ogee crest elevation	m	806	815	650
Discharge	m^3/s	5'500	3'250	8'200

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ILISU DAM AND HEPP
Table 2 - 6
Salient features of the Silvan, Kayser and Batman Dam Projects (Continued)

Power Intake-Penstocks				
Number / Length	m			1 / 332
Diameter	m			9.5÷5.0
Type of control	-			Sliding gates
Dimensions of gates	m			7.5 x 9.5

Powerhouse				
Type	-			
TURBINES				
Inlet gate number /Type / Diameter	- / mm			
Number of units / Type	-	3 / Francis	3 / Francis	3 + 1 / Francis
Turbine axis elevation / Gross head / Net head	m			595.5 / 61.8 / 60
Rated discharge / Speed	m³/s / rpm			/ 134 /
Installed capacity	MW	3 x 50	3 x 30	3 x 64 + 1 x 6
Firm / secondary / Total energy	GWh	597 / 26 / 623*	259 / 81 / 341	196 / 287 / 483
Load factor		0.47	0.43	0.28
		(* before irrigation)		
GENERATORS				
Type / Exciter system	-	Vertical shaft / Synchro	Synchronous / Static	Vertical shaft / Synchro
Voltage / Frequency	kV / Hz	15 / 50		14.4 / 50
Maximum continuous rating	MVA			
TRANSFORMERS				
Number / Type	-			3 + 1 / Triphase
Capacity	MVA			66.7
Voltage ratio	kV / kV			14.4 / 154
TAILRACE CHANNEL				
Tailwater level minimum / maximum	m	658 /	699.2 /	596.5 / 602
Tailwater level at spillway design discharge	m			606

Switchyard				
Type	-			/ 154
Number / Voltage of incoming lines	kV			
Number / Voltage of outgoing lines	kV	/ 154	/ 154	
Auto transformer ratio	kV / kV			

TABLE 2- 6   PAGE 2/2

ILISU DAM AND HEPP
Table 2 - 7
Salient features of the Garzan Dam Project

Plant		Garzan
Item	Unit	Data-Feature
Hydrology		
River	-	Garzan (Tigris trib. L/B)
Catchment area	km^2	1'266
Average annual inflow / Discharge	Mio m^3/ m^3/s	830 / 26.3
Average elevation of catchment area	m	
Minimum / maximum temperature at site	^{0}C	
Reservoir		
Normal storage / Minimum operation level	m	776 / 721
Talweg level	m	666
Inactive / Active / Total storage	Mio m^3	20 / 145 / 165
Reservoir surface / length	km^2/ km	4 / 20
Dam		
Dam type	-	Rockfill
Crest elevation / Dam height	m	779 / 113
Crest length / width	m	360 /
Dam foot width	m	
Dam volume	Mio m^3	4.2
Diversion facilities		
Type of diversion tunnels	-	
Number / Inside dimensions / Length	m	
Capacity	m^3/s	
Inlet / outlet elevation	m	
Crest elevation of U/S / D/S cofferdam	m	
Spillway		
Type	-	Controlled overflow
Number / Type of gates	-	4 / Tainter
Number of chutes / Energy dissipation	-	
Ogee crest elevation	m	765
Discharge	m^3/s	2'400

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Power Intake-Penstocks		
Number / Length	m	
Diameter	m	
Type of control	-	
Dimensions of gates	m	

Powerhouse		
Type	-	
TURBINES		
Inlet gate number /Type / Diameter	- / mm	
Number of units / Type	-	
Turbine axis elevation / Gross head / Net head	m	
Rated discharge / Speed	m³/s / rpm	
Installed capacity	MW	90
Firm / secondary / Total energy	GWh	178 / 137 / 315
Load factor	-	0.24
GENERATORS		
Type / Exciter system	-	
Voltage / Frequency	kV / Hz	
Maximum continuous rating	MVA	
TRANSFORMERS		
Number / Type	-	
Capacity	MVA	
Voltage ratio	kV / kV	
TAILRACE CHANNEL		
Tailwater level minimum / maximum	m	
Tailwater level at spillway design discharge	m	

Switchyard		
Type	-	
Number / Voltage of incoming lines	kV	
Number / Voltage of outgoing lines	kV	
Auto transformer ratio	kV / kV	

TABLE 2 - 7   PAGE 2/2

Power Intake-Penstocks				
Number / Length	m	1 / 332		
Diameter	m	9.5÷5.0		
Type of control	-	Sliding gates		
Dimensions of gates	m	7.5 x 9.5		

Powerhouse				
Type	-			
TURBINES				
Inlet gate number /Type / Diameter	- / mm			
Number of units / Type	-	3 + 1 /Francis		
Turbine axis elevation / Gross head / Net head	m	595.5 / 61.8 / 60		/ 185 /
Rated discharge / Speed	m³/s / rpm	/ 134 /		
Installed capacity	MW	3 x 64 + 1 x 6	90	55
Firm / secondary / Total energy	GWh	196 / 287 / 483	178 / 137 / 315	27 / 257 / 284
Load factor	-	0.28	0.24	0.59
GENERATORS				
Type / Exciter system	-	Vertical shaft / Synchro		
Voltage / Frequency	kV / Hz	14.4 / 50		
Maximum continuous rating	MVA			
TRANSFORMERS				
Number / Type	-	3 + 1 / Triphase		
Capacity	MVA	66.7		
Voltage ratio	kV / kV	14.4 / 154		
TAILRACE CHANNEL				
Tailwater level minimum / maximum	m	596.5 / 602		
Tailwater level at spillway design discharge	m	606		

Switchyard				
Type	-			
Number / Voltage of incoming lines	kV	/ 154		
Number / Voltage of outgoing lines	kV			
Auto transformer ratio	kV / kV			

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Ilisu Dam and HEPP
Environmental Impact Assessment Report

Photographs for Section 2

Ilisu Engineering Group
April 2001

Ilisu village and Tigris valley downstream of the damsite

Ilisu village

Thermal spring facilities at the left bank downstream of the damsite

Surroundings of Ilisu village

Old Hasankeyf bridge from upstream

Ilisu village