Key Issues:

11- Benefits due to Power Generation

Climatic Zone: Bsk : Semi-arid, steppe

Subjects:

- Large Scale Multipurpose Development

Effects:

- Hydropower Generation
- Fisheries in Reservoir
- Navigation
- Flood Control
- Development Regional Industries



Keban Dam

Project Name:	Keban Dam and Hydroelectric Power Plant (H.E.P.P.)
Country:	Turkey

Implementing Party & Period

- Project:	State Hydraulic Works (DSI)		
	1975 (Completion of construction) -		
- Good Practice:	State Hydraulic Works (DSI)		
	1975 (Commencement of operation)		

Key words:

Power Supply, Multipurpose Dam, Industrial Development

Abstract:

The Keban Dam and HEPP was constructed on the Euphrates River in 1975, being a major contributor to the solution of the energy problem in Turkey and considered to have been realized very economically, and was one of the most frequent subjects in Turkey during the early 1960s. The most important feature of the project is that it is the first huge result of engineering and planning natural resources for improvement of Turkish nation's welfare since 1930s. The dam has increased the self-confidence of the people living in the region through utilization for various purposes; power generation, fishery in the reservoirs, irrigation during drought periods, etc.. The dam has opened new horizons for developments of other water resource development projects in Turkey.

1. Outline of the Project

Upon the decision to utilize water resources in a rational manner and to meet the needs for electricity in particular appeared on the forefront as one of the most urgent issues, the Electricity Survey Administration (EIE Idaresi) was established in 1936 to produce energy from otherwise vainly flowing streams of the country. The Administration started its preliminary surveys intensively with the "Keban Project". In order to carry out studies on the river Euphrates with respect to various characteristics, the Administration established gauging stations on various points along the river. Geological and topographical works over the narrow passage of Keban started in 1938. Then, in the period 1950-1960, emphasis was shifted by the EIE on drillings on the Euphrates and the Tigris.

Later, upon the emergence of new needs, another organization, the State Hydraulic Works (DSI) was established in 1954 and took over the responsibility of development of Keban Dam and HEPP. Its construction started in 1965 and was put in operation in 1975 by DSI. The construction consortium was consisted of Compagnie de Constructions Internationales, Impresit-Girola-Lodigiani, Compagnie Français d'Enterprises, and ARI Construction.

The Keban Dam and HEPP is located at 45 km north west of Elazığ, 65 km north east of Malatya, 10 km from the confluence of Karasu and Murat tributaries and at 3 km upstream of Keban town, Elazığ province. The water enters the Keban Dam reservoir through the tributaries Karasu and Murat from catchment area of 64,100 km² with 150 km wide and 425 km long.



Figure 1: Location of Keban Dam and HEPP

The dam is founded on metamorphosed rocks of Paleozoic Period, which had been exposed to a lot of tectonic incidence. At the top white and pink colored, karstic and karstified calcareous and marble and below calcareous schist and dolomitic black lime stone layers are present. This formation was deformed by a lot of faults and breaking systems. One of these faults caused the fall of the ground in about 110 m and formed a narrow deep valley there. For this reason evaporation lose from water surface area of Keban dam is considerably less than that of dams which has large water surface area.

The dam is a mixed structure formed of two different dam types, rock fill dam and concrete gravity dam. The rockfill section forms the main dam. The length of this section is 601.00 m from the right bank rock surface to the north gravity blocks. The concrete part including intake and spillway is 524.00 m long. Total crest length is 1,125.00 m. The rockfill part is composed of clay-cored and compacted rock of 211 m high from the foundation. On the upstream and downstream side of the clay, there is fine and coarse filter of 4 m thick each. The rockfill shell is graded with the fine fill inside and coarse fill outside, forming a transition. Cross section of rockfill dam is shown in Figure 2. Diversion tunnels, intake structure and spillway are arranged on the left side of the valley. The power intake, spillway and gravity blocks were designed to complete the integrity of the structure and to conform to the topography. Trashrack structures are arranged on the upstream side of the power intake blocks. The spillway has 6 radial gates for a discharge capacity of 17,000 m³/sec in total. Water discharged through the spillway is channeled to the downstream through a 124 m wide and 400 m long chute and a flip bucket at the end of this chute.



Figure 2: Section of Rockfill Part

The power plant has a capacity of 1,330 MW, equipped with 8 units, first four of each 157.5 MW and other four units installed later on of each 175 MW capacity. It began generating power in 1975 and has produced almost 176.4 billion kWh until now. Specifications of Keban Dam and HEPP is shown in Table 1.

	Item	Specification
Power Plant	Start of Operation	October 1975
	Ave. Annual Generation	6,000 GWh
	Max. Output	1,330 MW
	Max. Power Discharge	135.32 m ³ /sec
	Max. Effective Head	145 m
Dam	Туре	Centralized Clay Rockfill+Concrete
	Crest Length	1,125.72 m
	Max. Height	210.86 m
	Volume	15,585,000 m ³
	Design Flood Discharge	17,000 m ³ /sec
Reservoir	Catchment Area	64,100 km ²
	Impounding Area	675 km ²
	Max. Capacity	30.6 billion m ³
	Max. Water Level	845.00
	Min. Water Level	800.00

Table 1: Specifications of Keban Dam and H.E.P.P

2. Features of the Project Area

The watershed includes upstream reach of the Euphrates River, Karasu tributary from Erzurum and Murat tributary from Mt. Ararat at around 4,500m height. The average slope of the rivercourse is 2 m per kilometer with total length of 2,800 km in the watershed. The topography of the area is changeable. Before arriving at the project site, the Euphrates valley is quite wide and shallow, but immediately it nears the Keban Gorge, it narrows and the valley walls are highly steep. Here, right and left abutments consist of completely bare and steep rocks. At the dam axis, the thickness of alluvium is about 45 m.



Figure 2: Upstream river system of the Euphrates River

The dam site is the most suitable area from the topographical point of view, from the confluence of Karasu and Murat tributaries together with Munzur and Peri creeks, which merge and form the Euphrates River at 3 km upstream of Keban town, Elazığ province. From this confluence point to Syrian border, the length of Euphrates river is 1,263 km.

The Euphrates River has a highly varying flow pattern throughout the year. Average water discharge is 635 m3/sec and 70 % of the annual flow of the river is in the season of snow melt, i.e. March and June. Maximum flow rate is observed in April and May. The concentration of discharge over the two months causes not only extensive spring flooding, but also the loss of much-needed water required for irrigation and power generation purposes during summer season. According to data measured in the Birecik gauging station near the Syrian border, average annual discharge in the long run is 31.6 billion m^3 . The climate in the region is semi-arid, steppe. The annual mean precipitation in the region is 436 mm, and the annual mean temperature varies from -1,5 °C in January to 27,2 °C in July.

The population of the project area increased due to the beginning of dam construction and service roads in 1964 and during the construction, it reached to 10,000. But after the dam construction completed, it decreased and the population of Keban district is 4,000 at present.

There was Simli Lean Enterprise in the center of Keban district before and during the construction of dam. But in 1980, it was closed because of inadequate reserve of ore. After enterprise was closed to operation the buildings were transferred to Firat Univercity. The project area has been underdeveloped and has lagged far behind the rest of the country in terms of all development indices. Implementation of the Keban Dam and HEPP and the following the Southeastern Anatolia Project greatly improved the economy and the life style of the region.

Industry in the region is based on agriculture. There are meat, sugar and cement factories in many cities around Keban. Cigarette in Malatya and Bitlis, fertilizier in Elazığ and leather industry in Erzurum and Malatya has developed distinctively. Textile and thread factories is situated in Malatya and Erzincan. Lead factory in Keban, Iron & steel factories in Divriği and ferro chrom factory in Elazığ are important enterprises for industrial development in the region together with use of electricity.

3. Benefits

3.1 Power Generation

The necessity of electric energy was 18,153 GWh between the year 1956 and 1962 in Turkey. It was increasing 13 percent every year and the requirement of it would be 82,025 GWh in the period of 1963-1973. For this reason the Keban Dam and HEPP is a very important project to produce electricity for Turkey. Total produced energy since 1975 is 176,400 GWh, with average energy

Year	Energy Production of Keban HEPP (GWh)	Total Energy Production of Turkey (GWh)	Percentage (%)
1976	4,485	18,282	25
2000	5,000	124,920	4
2001	3,648	122,725	3
2002	5,100	129,400	4
2003	6,025	140,580	4
2004	7,900	151,306	5

Table 2: Yearly Energy Production of Keban HEPP

production of 6,000 GWh per year. After the operation of Keban dam, additional energy production is 6,000 GWh per year. (mean energy production until 2000)

In parallel with construction of the Keban Dam and HEPP, 380km transmission lines were constructed to connect Keban, Ankara and Istanbul, and electricity generated contributed to improvement of economy of not only the region but also the country as a whole.

3.2 Fishery

Reservoirs constitute one of the prime fishery resources of Turkey in terms of their vast area and enormous production propensity. These open water systems allow quick increase in a catch at low capital/environment cost and fisheries development of these big water bodies directly bring benefits to some of the weakest sections of society. These benefits are accrued through increase in yield and thereby improve the quality and living standards of poor fishermen/women. Unlike culture fishery, where income is shared between limited investors, in reservoir fishery, the cream of augmented yield is more or less equitably distributed among the masses. This being a community based development process has a direct bearing on our rural economy.

In the Keban Dam Reservoir, one of the largest man-made reservoirs in Turkey, a reservoir field survey prior to impounding and limnological studies have been completed in 1970's and 1980's. Fish stocking activities into the reservoir have been continuing since 1982. Approximately 12 millions of some warmwater fish species fingerling, propagated in the DSI Keban Fish Hatchery, introduced into the reservoir. Total commercial fishing capacity of the reservoir is 4,000 tons and a market value of approximately 6 million USD. In fishery sector it may provide an employment of 900 people. For transportation purposes, several ferries are operated in the reservoir.



Photo 1: Fish hatchery

3.3 Irrigation

Between 1937 and 1993, prior to the Keban Dam operated, two drought periods had occurred. The first drought period covered 1958-1962. The amount of discharge on the border of Turkey and Syria in 1961 decreased to 14.9 billion m³. This amount corresponded with 47 % of average annual discharge in the long run.

The second drought season started in 1970 and ended in 1975. The most drought year in the stated period was 1975. The annual discharge decreased to 18.8 billion m³. This amount corresponded with the 59 % of average annual discharge in the long run. In two drought periods, due to the Keban Dam under construction, the negative effects of drought years decreased not only in Turkey but also in Syria and Iraq. As an example; in 1989 (relatively drought year) if the Keban Dam had not been constructed, 20.8 billion m3 water annually would have been released across the border. This amount reached to 25.7 billion m3 by increasing 4.7 billion m3 due to regulation effect of the dam.

An Eyüpbağları irrigation scheme began operation in 1987. Most of the irrigation water required for the scheme has been supplied by the Keban Dam. Gross irrigation area of the scheme in 1987 was 2,000 ha. This area has been increased in the following years, and reached to 9,537 ha in 2003. Main crops in the irrigated area are sugar beet, fruit, cotton and melons. Cultivation areas of these crops in terms of several years have been shown in Table 3 and Figure 3.

Years	Net Irrgiated Area (ha)				
	Irrigated	Sugar beet	Fruit	Cotton	Melons
1988	1,836	548	71	787	77
1993	2,951	1,559	138	330	252
1998	3,098	1,793	293	311	262
2003	1,905	918	275	138	176

Table 3: Cultivated Areas of Main Crops



Figure 3: Change in Cultivated Area and Agricultural Production

As shown in Table 3 and Figure 3, sugar beet is a main crop with 48 % crop ratio in the Eyüpbağları Irrigation Scheme. 14 % fruit, 9 % melon, 7 % cotton, and 22 % other crops have been cultivated in the irrigated area.

The irrigation ratio was 20 % in irrigated areas in this project developed by DSI including second crop areas and irrigated areas outside of the command area.

A yield increase in a unit area provided by irrigation is a unique element for increasing agricultural production value and added value. The yield increases in the Eyüpbağları irrigation scheme compared to without project situation are as follows: 190 % cereals, 250 % melon, 204 % cotton and 56 % sugar beet, respectively.

The increases in production value and the Gross National Agricultural Product (GNAP) obtained from the irrigation area have great importance for farmers. Increasing figures of these indicators for past 4 years can be seen in Table 4.

Years	Revenue	Without Project (USD/ha)	With Project (USD/ha)	Revenue Increase (USD/ha)
2000	Production Value*	58	1,585	1,527
	GNAP**	41	1,125	1,084
2001	Production Value	97	2,421	2,324
	GNAP	69	1,719	1,650
2002	Production Value	129	3,202	3,073
	GNAP	92	2,273	2,182
2003	Production Value	200	5,179	4,979
	GNAP	142	3,677	3,535

Table 4: Benefit of Eyüpbağları Irrigation Scheme

According to 2003 crop yields and prices, production value increase of 4,979 USD has been obtained per ha irrigated area. GNAP has also increased compared to that without project situation, and GNAP increase of 3,535 USD has been provided per ha irrigated area.

Contribution of irrigation schemes to employment is also significant for regional and national economy. One ha developed irrigated area provides additional employment for 2 people. Thus,

irrigation area of this scheme would ensure employment opportunities for about 20,000 people. Benefit/cost ratio is an indicator which shows the effectiveness of irrigation scheme. According to the most recent data, benefit/cost ratio of this scheme is 1.15.

*Production Value means that multiplication of crop yields obtained yearly in a unit agricultural area with the market prices of the crops.

**GNAP means that family labor force, taxes, amortization and operation costs per unit agricultural area are included in the production value.

4. Effects of the Benefits

As indicated above, the Keban HEPP has produced 6,000 GWh/year and this means that it has recovered its construction cost 7 times so far. As well as its energy production the project has also a potential irrigable area of 55,755 ha, and approximately 1,000 tons of fish production per year.

Before the operation of the dam, negative effects of two drought seasons in the upper basin were felt by the two riparian countries, Syria and Iraq. After construction, the dam has a function of regulating the Euphrates River. Since Keban dam is on the upstream part of Euphrates River, it also protects the other dams downstream which are under operation and construction in terms of flood. Additionally, workers and technical employees gained talent and found job during the construction of dam.

5. Reasons for Success

A hydropower project shall be planned so that it benefits the surrounding area and benefits shall not be taken away only to the metropolitan area. The Keban Dam and HEPP's economic activity and vitality was a mobilizing factor for the whole region. As stated above Keban dam provides hydroelectric power production, flood control and recreational opportunities for not only locally but also regionally.

Realization of Keban project resulted in the extension of Elazığ Airport, construction of a new avenue in the city of Elazığ, expansion of the cement factory, many public building projects. Relocation of roads and a railroad passing in the area which would be submerged under the reservoir were all financed within the Keban project budget.

6. Outside Comments

It can be stated some of specific outside comments on the GP made by newspapers and magazines, as follows:

THE CLAIRE FOSS JOURNAL

"In the 1960s, the KfW combined the functions of a development bank and an export credit bank. Using its extensive experience with the reconstruction of the West German economy after World War II, the KfW financed or co-financed countless projects for energy, water, and transport infrastructure, and development of agricultural and industrial production in Third World countries. Some of the most famous projects included the Rourkela steel plant in India, the nuclear power station Atucha I in Argentina, the Keban Dam in Turkey, the Lome Harbor in Togo, the Cabora Bassa hydroelectric project in Mozambique, the Roseires dam in Sudan, and others. There were countless smaller projects, from road-building and irrigation systems, to manufacturing plants."

7. Further Information

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