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SUMMARY

SUMMARY

This report concerns the feasibility study of the Oltu River Hydroelectric Power Development Project of the Republic of Turkey. The feasibility study has been conducted from 1990 to 1992 by the Japan International Cooperation Agency (JICA) under a technical cooperation program of the Government of Japan.

This report is submitted by JICA, through the Ministry of Foreign Affairs of the Japanese Government, to the General Directorate of Elektrik İsleri Etüd İdaresi (EİE) of the Government of Turkey.

A brief summary of the results of the feasibility study is presented in the following part of this section.

(1) Necessity for Development

The electric power facilities in the Republic of Turkey as of the end of 1990 amounted to 16,274 MW (86,761 GWh planned) of which hydroelectric power generating facilities were 6,755 MW (24,805 GWh planned) and thermal power generating facilities 9,519 MW (61,956 GWh), the ratio of the two being 42:58.

The results of forecasts made of future power demands (1991 to 2010) by the Turkish Electricity Authority (TEK) recently, and the results of forecasts made by the JICA Team are as follows:

	Macro Method Forecast		TEK Forecast	
	(MW)	(GWh)	(MW)	(GWh)
1990	9,281	57,116	9,340	57,563
1995	14,161	85,595	15,005	92,984
2000	21,032	125,285	33,435	139,213
2005	30,477	178,874	34,025	207,056
2010	37,707*	218,962*	50,600	307,964

* at 2008

In order to cope with these demands, it is necessary for development of about 3,000 MW to be continued hereafter up to the year 2010, and for this purpose, it is planned for supply to be made not only by lignite fired thermal, but also by thermal power using imported coal and imported gas, while it is necessary for hydroelectric power development to be aggressively pushed to meet about a half of the total power demand. Hydroelectric power stations to be commissioned in the near future are Atatürk (300 MW x 8 = 2,400 MW) in 1994, Batman (64 x 3 = 192 MW) in 1994, and Çatalan (56 x 3 = 168 MW), Gezende (53 x 3 = 159 MW), and Menzelet (31 MW x 4 = 124 MW) in 1993. Meanwhile, hydroelectric sites such as Berke (510 MW), Kayraktepe (420 MW), Ilısu (1,200 MW), Boyabat (510 MW), Birecik (670 MW), and Yedigöze (300 MW) are being prepared for start of construction. Also, in succession to the above, preparations for hydroelectric power development at Deriner (670 MW) and Yusufeli (560 MW) are scheduled to be started aiming for commissioning in the first half of the 2000s. However, it is desirable for a power transmission network to be built up for smooth transmission of power from these power stations to demand areas.

With regard to the Oltu hydroelectric power stations it may be considered that start-up should be around the year 2005 as soon as possible after start-up of Yusufeli Hydro in view of the physical schedule that electric power obtained from development of the Çoruh River is to be sent to the western and southern parts of Turkey. Furthermore, it is thought that the series of development according to the Oltu Hydroelectric Project will greatly contribute to economic development of the area concerned.

(2) Meteorology and Hydrology

The Oltu River Basin in which the Oltu project sites are located is closed off from the Black Sea by the Doğu Karada which runs parallel to the Çoruh River Mountain Range, and belongs to a region of typical continental climate having little rainfall and severe highs and lows of temperature.

The meteorological characteristics of this region are as mentioned above with annual average rainfall 400 mm, 50% of annual rainfall, or 200 mm falling in the rainy season from April to July. Snowfall has been recorded between November and April. The mean annual temperature is 9.8°C with a rise to a maximum of 39°C in the summertime, while in the wintertime the minimum temperature becomes lower than -20°C.

The runoff of the Oltu River is small due to the above-mentioned meteorological conditions, the average annual inflow at the Olur dam site being 655 x 10^6 m^3 and that at the Ayvalı dam site 813 x 10^6 m^3.

The meteorological and hydrological quantities at the individual project sites according to analyses of meteorological and hydrological data are as given below.

	Olur Project	Ayvalı Project
Catchment area :	3,509 Km^2	4,517 Km^2
Elevation of riverbed:	1,025 m	810
Temperature Maximum :	39°C	
Minimum :	-24°C	
Annual Average Pre-capitation :	300 - 500 mm	
Annual Inflow :	655 x 10^6m^3	813 x 10^6m^3
Annual average dis-charge :	20.8 m^3/s	25.8 m^3/s
Annual evaporation from reservoir surface :	843 mm	867 mm
Suspended load :	279 ton/yer/km^2	279 ton/yer/km^2
Design sedimenta-tion 50 years :	47 x 10^6m^3	61 x 10^6m^3
100 years :	94 x 10^6m^3	121 x 10^6m^3
Probable maximum flood (PMF)	4,750 m^3/sec	5,270 m^3/sec
25-year return period flood :	332 m^3/sec	376 m^3/sec

(3) Topography

Of the Olur project area, the part to become the reservoir has a topography which is comparatively gentle, but the topography of the area from the dam to the powerhouse is extremely steeply sloped and other than the river-bed portion there is hardly any vegetation, volcanic rocks being exposed to present a very rugged appearance. There are river terrace flats and fans developed, upon which there is social life going on. Inside the river-bed it is fairly wide with sand-gravel deposited in large quantity, the thickness being estimated to be considerable.

The river from the dam site to the powerhouse runs north at first, after which it changes course making a large bend to go west, and after passing the Ayvalı dam site, merges with the Çoruh River. The river gradient from the dam site to the powerhouse is fairly steep at 1/200 to 1/130.

Almost all the area of the Ayvalı project, including the reservoir, dam, powerhouse, and tailrace, lies in an area of the Ayvalı Formation which consists of volcanic rocks, with a part of the tailrace passing through the Pügey Formation of sedimentary rocks. The topography of the project area is very steeply sloped similarly to the topography of the Olur Project from the dam to the powerhouse with practically no vegetation other than the river-bed portion, rocks being completely exposed, and mountains closing in on the river to present a very rugged appearance.

The river-bed portion, excepting the sedimentary plain dammed up by the narrow gorge at Sakartepe, is very narrow. The thickness of river deposits is also fairly great. River-bank terraces exist at parts along the river bank from the dam to the tailrace outlet, and social activities are going on at the terraces. The river from the dam site to the outlet runs roughly westward while meandering down to join the Çoruh river. The river gradient from the dam site to the tailrace outlet is about 1/90, while especially, the river gradient from Sakartepe to the outlet is approximately 1/40.

Between the dam site and the tailrace outlet site, there is the Civan Dere merging from the left-bank side 2 km downstream from the dam, and 5 km further downstream the Anzav Dere (downstream of Sakartepe) joins in, while at the right-bank side, there is the Bulanik Dere 7 km downstream from the dam (upstream of Sakartepe).

(4) Geology and Materials

- Geology

The geology of the project area was affected by the Hercynian orogeny in the Paleozoic Carboniferous Period and the Alpine orogeny in the Cenozoic Era. The geology is composed of Quaternary deposits, the Tertiary Oltu Formation (sedimentary rocks), the Mesozoic Pügey Formation (sedimentary rocks), Ayvalı (volcanic rocks), and Yusufeli Formation (igneous rocks and metamorphic rocks).

The foundation rocks at the principal structures projected are roughly as given below.

1) Olu Project

SITE	GEOLOGY
Reservoir	Yusfeli formation (gabbro, greenschist etc.) Ayvalı volcanic rocks (rhyolite, tuff) Oltu formation (claystone, sandstone, conglomerate)
Damsite	Ayvalı volcanic rocks (rhyolite, diabase, granite porphyry) * River deposit is thick
Headrace Tunnel	Ayvalı volcanic rocks (lava, rhyolite, tuff, volcanic breccia)
Surge Tank Penstock Powerhouse	Ayvalı volcanic rocks (lava, volcanic breccia)

The geology of Olur Reservoir and its vicinity is composed of gabbro and green schist of the Yusufeli Formation, lava, rhyolite, and tuffs of the Ayvalı Formation, and claystone, sandstone, and conglomerate of the Oltu Formation. Rocks which may cause leakage from the reservoir as pure limestone are not distributed around the reservoir area. Large-scale landslides expected to cause waves such as would affect safety of the dam are not seen in the surroundings of the reservoir.

The geology at the dam site consists of granite porphyry, rhyolite and diabase, and there are no problems from the standpoints of securing strength and impermeability as a foundation for a dam of 136 m height. River deposits would be the foundations for rock zones of a rockfill dam, but it is thought there will be no problem from the standpoint of strength.

The sites of principal structures such as the headrace, surge tank, penstock, and powerhouse are in the Ayvalı volcanic rocks, and it is considered there is no problem geology-wise that would be an obstacle to implementation of the project.

2) Ayvalı Project

SITE	GEOLOGY
Reservoir	Ayvalı volcanic rocks (lava, rhyolite, tuff, volcanic breccia) Pügey formation (alternation of marl and limestone)
Damsite	Ayvalı volcanic rocks (volcanic breccia, tuff, rhyolite) * River deposit is thick
Powerhouse	Ayvali volcanic rocks (tuff breccia, rhyolite)
Tailrace Tunnel	Ayvalı volcanic rocks (lava, tuff, volcanic breccia, rhyolite) Pügey formation (alternation of marl and limestone)

The geology of Ayvali Reservoir and its vicinity is composed of lava, rhyolite, tuff, and volcanic breccias of the Ayvalı volcanic rocks. Large-scale landslides expected to cause waves such as would affect safety of the dam are not seen in the surroundings of the reservoir. Furthermore, there are no places seen where leakage from the reservoir would occur.

The geology of the dam site consists of tuff, volcanic breccias, and rhyolite, and there will be no problem about securing strength and impermeability as the foundation for a dam of height around 175 m. River deposits would be the foundations for rock zones of a rockfill dam, but it is thought there will be no problem from the standpoint of strength.

The powerhouse would be provided in the tuff breccias and rhyolite of the Ayvalı volcanic rocks as an underground structure, and it will be amply possible for excavation of a large cavern to be performed.

Approximately 7 km on the upstream side the tailrace tunnel would be provided in the Ayvali volcanic rocks, and approximately 2.5 km on the down stream side in the Pugey Formation. Both formations are very sound and there will be no problem about providing the waterway. The tailrace tunnel passes the large Anzav valley. However, the bedrock above the tunnel location is confirmed to be more than 30 m by geological investigations and it is considered that construction can be done with ample safety.

- Materials

1) Olur Project

The Kaledibi Borrow Area approximately 3 km upstream of the dam and the Yolboyu Borrow Area approximately 8 km upstream are planned to be used to obtain impervious solid core material of the dam. The material of the former is slightly on the coarse-grained side and that of the latter slightly on the fine-grained side. If necessary, it is conceivable for the two to be blended and used. Material excavated from the river-bed sand-gravel would be used for the fine-grained filter of the dam, while for the coarse-grained filter, material excavated from the spillway and sites would be used.

Material excavated from the river-bed sand-gravel would be used for the fine-grained filter of the dam, while for the coarse-grained filter, material excavated from the spillway and sites would be used.

For rock embankment materials, granite porphyry at the right bank downstream of the dam would be excavated, collected, and banked.

For concrete aggregates, the river-bed sand-gravel excavated from the dam site can be screened and used. Furthermore, there is a large amount of sand-gravel existing in the river bed around the dam, and this can be amply used.

2) Ayvalı Project

Borrow areas are planned at the Bulanik Dere 8 km downstream of the dam and Tavsker 8 km upstream of the dam for impervious soil core material of the dam. The material of the former borrow area has scattering of properties depending on the stratum and the location,and it will be necessary for improvement to be made by blending before use. The material of Tavusker is high in the content of fines.

As fine-grained filter for the dam, excavated material from the river-bed sand-gravel, and as coarse-grained filter, excavated material from the spillway, dam, etc. are to be used.

For rock embankment material of the dam a quarry is to be provided immediately upstream of the dam.

As concrete aggregate the river-bed sand-gravel at the dam can be screened and used. There are also large amounts of sand-gravel at the river bed in the surroundings of the dam, and these can be amply used.

(5) Earthquakes

In order to decide on the design seismic coefficient a predictive evaluation was made by statistical analysis of the maximum acceleration at the ground surface at the Oltu site. The earthquake data used in this predictive evaluation had been gathered by the Environmental Data Service of NOAA (National Oceanic and Atmospheric Administration) of the United States, and the numbers of earthquake data during the period from 1901 to 1987 within radii of 200 km from the dam sites were 3,742 for Olur Dam and 3,402 for Ayvalı Dam.

The Oltu sites are located in an earthquake risk zone of [II] in the seismicity map prepared by the Government of the Republic of Turkey (IMAR ve ISKAN BAKANLIGI, 1972).

Therefore, considering here the results of stochastic analyses also, it was decided to set the design horizontal seismic coefficient of the Oltu sites (Olur Dam and Ayvalı Dam) as 0.15.

(6) Survey for Environmental Assessment

The effect of the project on the natural and social environments in and around the project area was qualitatively studied by surveying the present situation through the site survey of and the literature search for the natural and social environments.

- Natural Environment

1) Nature Conservation

There is no national park and no nature conservation area in and around the project area. A game reserve is located north of National Road 060, but a part of this reserve located inside the project site is very small. There is an area with restrictions on the catch of fishes, but the area is not located inside the project site. Therefore, the execution of the project will have almost no effect on the natural environment.

2) Natural Scenery

The natural scenery in and around the project area consists of a brown and turbid river, houses which dot flat land along the river, pastures, cultivated land, its deep gorge and dry mountainsides.

The appearance of the dam and its reservoir seems to create a new waterfront beauty spot.

3) Vegetation

As for flora in and around the reservoir area, forests are limited and vegetation is poor except forest zones on the summits of mountains and orchards and poplar lines along the river. Plants regarded as precious are not seen either.

Trees in orchards and poplar lines along the river will be cut down to locate the power station building and the reservoir.

4) Animals

As for land animals living in and around the reservoir area, there are rabbits, goats, sparrows, crows, snakes, lizards, frogs, and others, but no precious land animals specified to be protected.

As for aquatic animals, there are carp, trout, aquatic insects, and so on. There is an area with restrictions on the catch of fishes. But it is not located inside the project site.

5) Water Quality

The main causes of water pollution during the construction work period are imagined to be waste water from temporary facilities such as concrete plant and spray plant as well as waste water from earth excavation and concrete work. It is possible to decrease the effect of waste water on the natural environment by discharging waste water after being treated as much as possible.

There will definitely be no eutrophication after the power station starts to be in operation since large-scale artificial pollution sources are not seen upstream from the project site. However, great care should be given to the amount of nitrogen compound which may be artificially added to daily living waste water from the power station and others since the concentration of phosphorus compound from nature is high now. The river will not be turbid for a long time since pollutant in the river mainly consists of silt which is expected to sink almost completely in the reservoir.

The appearance of the reservoir is expected to create a new living environment for aquatic life.

6) Noise, Vibration and Air Pollution

The main noise and vibration sources as well as air pollution sources during the construction work period seem to be construction equipment, trucks used for transporting equipment and materials, and dust from bare land such as excavation places. It is possible to decrease the effect of them on the natural environment by using low-noise and low-vibration machines as much as possible and by taking proper measures against exhaust gas and dust.

There will be no effect on the natural environment after the power station starts to be in operation since few machines which may cause noise and vibration are expected to be used and facilities and machines which may become air pollution sources are expected to be hardly used.

• Social Environment

1) Industrial Activities and Land Utilization

The number of households inside the planned reservoir site is about 600, and the area of land required to be obtained is about 6,500Da. The land required to be obtained is now used as cultivated land with an area of about 3,500Da., pastures with an area of about 1,500Da., and orchards with an area of about 1,000Da.

It is desirable to deliberate with the persons concerned about land acquirement and give adequate compensation to them in carrying out the project.

There are almost no commercial activities in this area. Their economy is expected to become activated during the construction work period and after the power station starts to be in operation since more people are expected to come to this area, then commercial activities are expected to be carried out and employment is expected to be given to residents.

2) Transportation and Public Facilities

The transport of equipment and materials for construction work is expected to increase the volume of traffic temporarily. There seems no big effect on the volume of general traffic since the volume of traffic is generally not so big. However, great care should be given to traffic safety measures such as the strict observance of safety speed since big trucks are expected to run.

A part of the national road and others will be submerged and then substitute roads will be constructed. Public facilities such as schools and mosques inside the area planned to be submerged should be relocated according to residents' intention.

3) River System Utilization

River water inside the project area is mainly used as irrigation water. It is necessary to exercise temperature control before discharging water from the reservoir. The formation of the reservoir will give a new living space for fishes.

4) Cultural Assets and Recreational Facilities

There are no historical remains and no recreational facilities, which are expected to be submerged together with the appearance of the reservoir. After the power station starts to be in operation, the project site for the dam and the power station and its vicinity seem to be used as recreational facilities.

- Conclusion

According to the results of the survey, the execution of the project seems not to have a big effect on the natural environment except residents who are now using the future submerged area as their living places.

As for the execution of the project, it is desirable to deliberate sufficiently with residents who have to leave the submerged area or the organization concerned, to give adequate proper compensation to them and to give consideration to residents who will remain to live in the vicinity of the submerged area.

The required expenses are estimated in the compensation cost.

(7) Outline of Optimum Development Plans

Review was made of the existing Master Plan, and studies were carried out based on existing investigation data and detailed additional data, and the optimum development plans described below were selected from among a number of development plans.

The Oltu Hydroelectric Power Development Project consists of a two-stage development plan made up of the two projects of Olur Hydroelectric Power Station and Ayvalı Hydroelectric Power Station, therefore optimization of the Oltu Project was carried out in the manner that the combination of the two projects as a whole would be most optimum.

- Olur Project

The Olur Project is the upstream project in the two-stage development of the Oltu River.

It is planned for a rockfill dam 136 m in height and 3.8 x 10^6m^3 in volume to be constructed at the point of catchment area of 3,539 Km^2 to obtain a effective storage capacity of 200 x 10^6m^3. An annual average inflow of 565 x 10^6m^3 is to be regulated by means of this reservoir.

A maximum discharge of 48 m^3/s is to be drawn from an intake provided at the left bank side immediately upstream of the dam, this water is conducted to a powerhouse provided at a left bank through a headrace tunnel approximately 9 km in length and penstock to obtain a maximum output of 65 MW and annual energy production of 242 GWh by utilizing effective head of 154.7 m. Fig. 9-15 shows the result of the optimization study on the effective storage capacity and the high water level. Fig. 9-17 shows the result of the optimization study on the installed capacity. Fig. 9-20 shows reservoir operation result and Fig. 9-2 shows monthly peak power and annual energy production. The energy generated at the Olur Project is to be sent to Yusufeli Swtchyard via the Ayvalı Switchyard by a 154 KV transmission line, from where transmission is to be made to load area by 380 KV transmission line.

- Ayvalı Project

The Ayvalı Project is the downstream project in the two stage development of the Oltu River.

It is planned for a rockfill dam 175 m in height and 9.3 x 10^6m^3 in volume to be constructed at the point of catchment area of 4,517 km^2 to obtain a effective storage capacity of

150 x $10^6 m^3$. An annual average inflow of 813 x $10^6 m^3$ is to be regulated by means of this reservoir.

A maximum discharge of 67 m^3/s is to be drawn from an intake provided at the left bank side immediately upstream of the dam, this water being conducted to a underground powerhouse provided at the left bank through a penstock to obtain a maximum output of 125 MW and annual energy production of 409 GWh by utilizing effective head of 211.8 m. After generation, this water is discharged to the Yusufeli Reservoir through a tailrace tunnel approximately 10 km in length. Fig. 9-16 shows the result of the optimization study on the effective storage capacity and the high water level. Fig. 9-18 shows the result of the optimization study on the installed capacity. Fig. 9-22 shows reservoir operation result and Fig. 9-23 shows monthly peak power and annual energy productions. The energy generated at the Ayvalı Project is to be sent to Yusufeli Switchyard by a 154 kW transmission line, from where transmission is to be made to load area by 380 kV transmission line.

(8) Construction Schedule and Construction Cost

- Construction Schedule

Commissioning year of the Oltu Project is appropriate at around 2006 considering necessary periods of additional field investigation works, detailed design, financial formulation and construction of the project as shown below.

Nov. 1990 - Oct. 1992	Feasibility Study
Nov. 1993 - Oct. 1994	Provision and Award of Final Design (1 year)
Nov. 1994 - Oct. 1995	Final Design (2 years)
Nov. 1996 - Oct. 1997	Financial Formulation (1.5 years)
Nov. 1997 - Oct. 1999	Bidding and Award of Contract for Construction (1.5 years)
Nov. 2000 -	Start of Construction of the Olur and Ayvalı Projects
Dec. 2005 -	End of Construction of the Olur Project
Jun. 2006 -	End of Construction of the Ayvalı Project

The construction works of the Oltu Project will require periods of approximately 6 years for Olur Project and approximately 6.5 years for Ayvalı Project as a result of studying the scale of construction, layout of structures, preparatory works, etc. Work Schedules at the Projects are given in Fig. 12-3 and 12-4.

- Construction Cost

The construction cost of the Project was estimated, considering that designs and construction methods, and materials and products of the levels that can be expected at this time, would be used. Furthermore, estimates were made giving consideration to geological conditions, topographical conditions, and project scale. The time of estimation was taken to be July 1991. The exchange rate used was US$1.00 = 4,300 TL.

1) Olur Project

With the total construction cost as 677,364 x 10^6 TC (US$ 157.5 x 10^6) the breakdown of local and foreign currency requirements is 413,190 x 10^6 TL (US$ 96.1 x 10^6), 264,174 x 10^6 TL (US$ 61.4 x 10^6) respectively.

2) Ayvalı Project

With the total construction cost as 957,688 x 10^6 TL (US$ 222.7 x 10^6) the breakdown of local and foreign currency requirements is 534,046 x 10^6 TL (US$ 124.2 x 10^6), 423,642 x 10^6 TL (US$ 98.5 x 10^6) respectively.

3) Total Project

With the total construction cost as 1,635,052 x 10^6 TL (US$ 380.3 x 10^6) the breakdown of local and foreign currency requirements is 947,236 x 10^6 TL (US$ 220.3 x 10^6), 687,816 x 10^6 TL (US$ 160.0 x 10^6) respectively.

Detailed construction cost is as shown in Table 12-6.

(9) Economic Evaluation and Financial Analysis

Development of the Olur Project and Ayvalı Project will be implemented simultaneously. Optimization of the project was carried out in the manner that the combination of the two projects as a whole would be most optimum. No consideration has been made in the case that the Olur and Ayvalı Projects would be developed individually.

Therefore, the result of economic and financial analyses should be evaluated about the Oltu Project as a whole.

1) Economic Evaluation

As the method of the economic evaluation of this project, an alternative plant approach is employed to measure and evaluate economic costs of the proposed project and the alternative project.

The results of evaluation of EIRR, B-C and B/C of the Olur and Ayvali projects and the combined project are as follows:

	EIRR	B - C	B/C
Olur Project	18.72%	137,774 x 10^6 TL (US$ 32.0 x 10^6)	1.33
Ayvalı Project	33.05%	401,170 x 10^6 TL (US$ 93.3 x 10^6)	1.71
Combined Total Project	26.82%	538,944 x 10^6 TL (US$ 125.3 x 10^6)	1.54

As indicated by indices B-C and B/C of the combined project, the costs of construction and operation of the project are much smaller than those of an alternative thermal power plant which can provide equivalent service, and it can be also concluded that the project can continue to maintain its superiority as long as the discount rate which reflects the capital opportunity cost does not exceed 26.82%.

2) Financial Analysis

For the financial analysis of the project, "Financial Evaluation from Viewpoint of Total Investment-Calculation of the Financial Internal Rate of Return" is analyzed and judgement is made for evaluation.

FIRRs of the Olur Project and the Ayvalı Project are 9.87% and 11.25% respectively and that of the combined project is 10.68%.

Judging from the FIRR of the combined total project, the project is sound from the financial point of view.

Summary of Olur Hydroelectric Power Development Project

Item	Unit	Description
Location		Oltu River
Catchment Area	km^2	3,509
Annual Inflow	10^6 m^3	655.7
Design Flood	m^3/sec	4,750
Reservoir		
Normal High Water Level	m	1,105
Low Water Level	m	1,077
Available Drawdown	m	28
Sedimentation Level	m	1,077.2
Gross Storage Capacity	10^6 m^3	293.5
Effective Storage Capacity	10^6 m^3	200.0
Reservoir Area	km^2	10.7
Diversion Tunnel		
Diameter	m	6.0
Length	m	530
Design Flood Discharge	m^3/sec	332
Number		1
Dam		
Type		Rockfill with center core
Crest Elevation	m	1,110
Dam Height	m	136
Crest Length	m	328
Dam Volume	10^3 m^3	3,818

Item	Unit	Description
Spillway		
Type		Gated Chute
Spillway Capacity	m^3/sec	4,750
Number of Gate	set	3
Dimension of Gate	m	13.5 x 16.5
Intake		
Type		Inclined type made of reinforced concrete
Gate	set	Loller Gate 1
Headrace Tunnel		
Number		1
Type		Circular pressure
Diameter	m	4.9
Length	m	9,659
Surge Tank		
Type		Orifice
Diameter	m	12
Penstock		
Type		Steel penstock supported by ring-girder
Diameter	m	4.9 ~ 3.2
Length	m	436

Item	Unit	Description
Powerhouse		
Type		Semi-underground of reinforced concrete
Dimension	m	Width 17
	m	Length 30
	m	Height 27
Development Plan		
Standard Intake Water Level	m	1,095.7
Standard Tail Water Level	m	929.0
Gross Head	m	166.7
Effective Head	m	154.7
Maximum Discharge	m^3/s	48.0
Unit Capacity	MW	65
Number of Unit	unit	1
Installed Capacity	MW	65
Turbine		
Type		Vertical Shaft Francis
Number of Unit		1
Rated Output	MW	66.5
Revolving Speed	rpm	333

Item	Unit	Description
Generator		
Type		3-phase, AC, synchronous
Number of Unit		1
Capacity	MVA	74
Voltage	kV	11
Power Factor		0.9 lag
Frequency	Hz	50
Revolving Speed	rpm	333
Main Transformer		
Type		Outdoor, 3-phase transformer
Number of Unit		1
Capacity	MVA	74
Voltage	kV	11:154
Switchyard		
Bus Type		Single bus + Transfer bus
Voltage	kV	154
Circuit Breaker Type		Gas insulated
Transmission Line Section		
Number of Circuit		1
Voltage		154
Section		Olur switchyard - Ayvali switchyard

Item	Unit	Description
Annual Energy Production		
Firm Energy	GWh	126.5
Secondary Energy	GWh	115.0
Total Energy	GWh	241.5
Construction Period	years	6
Project Cost	10^6 T.L.	677,364 (US$157.5 x 10^6)
Unit Construction Cost		
per kW	T.L./kW	10,420,969
per kWh	T.L./kWh	2,804
Economic Internal Rate of Return (EIRR)	%	18.72
Financial Internal Rate of Return (FIRR)	%	9.87
Net Present Value (B-C)	10^3 US$	137,774
Benefit Cost Ratio (B/C)		1.33
Exchange Rate		1US$=4,300 T.L. (As of July 1991)

Summary of Ayvali Hydroelectric Power Development Project

Item	Unit	Description
Location		Oltu River
Catchment Area	km^2	4,517
Annual Inflow	10^6 m^3	813.0
Design Flood	m^3/sec	5,270
Regulating Reservoir		
Normal High Water Level	m	930
Low Water Level	m	908
Available Drawdown	m	22
Sedimentation Level	m	890.1
Gross Storage Capacity	10^6 m^3	354.8
Effective Storage Capacity	10^6 m^3	150.0
Reservoir Area	km^2	8.2
Diversion		
Diameter	m	6.0
Length	m	659
Design Flood Discharge	m^3/sec	376
Number		1
Dam		
Type		Rockfill with center core
Crest Elevation	m	935
Dam Height	m	175
Crest Length	m	444
Dam Volume	10^3m^3	9,268

Item	Unit	Description
Spillway		
Type		Gated Chute
Spillway Capacity	m^3/sec	5,270
Number of Gate		3
Gate Dimension	m	13.5 x 17.5
Intake		
Type		Inclined type made of reinforced concrete
Gate		Roller Gate 1
Penstock		
Type		Embedded steel pipe
Diameter	m	4.1 ~ 3.8
Length	m	288
Number		1
Powerhouse		
Type		Underground
Dimension	m	Width 19
	m	Length 44.5
	m	Height 42
Surge Chamber		
Type		Chamber
Dimension	m	Wide 5.4 m
	m	Length 100 m
	m	Height 11.7 m

Item	Unit	Description
Tailrace Tunnel		
Type		Horseshoe Circular Non-pressure
Diameter	m	5.4
Length	m	9,260.9
Development Plan		
Standard Intake Water Level	m	922.7
Standard Tail Water Level	m	700.0
Gross Head	m	222.7
Effective Head	m	211.8
Maximum Discharge	m^3/s	67.0
Unit Capacity	MW	125
Number of Unit		1
Installed Capacity	MW	125
Turbine		
Type		Vertical Francis
Number of Unit		1
Rated Output	MW	126.5
Revolving Speed	rpm	300

Item	Unit	Description
Generator		
Type		3-phase, AC, synchronous
Number of Unit		1
Capacity	MVA	140.6
Voltage	kV	14.4
Power Factor		0.9 lag
Frequency	Hz	50
Revolving Speed	rpm	300
Main Transformer		
Type		Outdoor, 3-phase
Number of Unit		4 (including 1 spare)
Capacity	MVA	47
Voltage	kV	14.4:154 $\sqrt{3}$
Switchyard		
Bus Type		Double bus
Voltage	kV	154
Circuit Breaker Type		Gas insulated
Transmission Line		
Number of Circuits		2
Voltage	kV	154
Section		Ayvali switchyard-Yusufeli switchyard

Item	Unit	Description
Annual Energy Production		
Firm Energy	GWh	248.0
Secondary Energy	GWh	161.4
Total Energy	GWh	409.4
Construction Period	years	6.5
Project Cost	10^6 T.L.	957,688 (US$222.7)
Unit Construction Cost		
per kW	T.L./kW	7,661,504
per kWh	T.L./kWh	2,339
Economic Internal Rate of Return (EIRR)	%	33.05
Financial Internal Rate of Return (FIRR)	%	11.39
Net Present Value (B-C)	10^6 T.L.	401,170
Benefit Cost Ratio (B/C)	-	1.71
Exchange Rate		1US$=4,300 T.L . (As of July 1991)

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This project site is on the midstream stretch of the Oltu River, a tributary of the Çoruh River which is located in the northeastern part of the Republic of Turkey and empties into the Black Sea, the project consisting of construction of two power development schemes.

As a result of studies made based on the data investigated up to the present, the conclusion was drawn that both the Olur Project and the Ayvalı project are feasible, technically and economically. The Contents of the conclusions are described below.

1) This Project is to be developed with the purpose of supplying plentiful and stable electric power which effectively utilizes water resources existing abundantly in Turkey, as purely indigenous resources which are practically nonpollutant. It is considered that going ahead with development of this Project will contribute to regional development.

2) The growth of power demand in the Republic of Turkey up to 1983 was blunted because of sluggished economics; however, annual growth at the 7.8 - 12.5% level was indicated from 1984 to 1990, and annual average growth rates from 1991 to 1995 and 1996 to 2010 are expected to be 10% and 8% respectively. Therefore, it is calculated that the peak demand at 2010 will be 50,600 MW.

3) As principal energy resources produced in the Republic of Turkey, there are the 5.7×10^6 ton of petroleum reserves, 12.9×10^6 ton of lignite reserves and 30,800 MW of hydroelectric power potential. Of this hydroelectric power potential, only 6,755 MW, 22% had been developed as of the end of 1990, and there is much being expected of

development hereafter of this clean and purely domestic energy resource, 20,100 MW is planned to be developed by 2010.

4) Review of the development scheme recommended by the Oltu River Master plan Report carried out and appropriate selection of development layout, development scale and development time was implemented. Development of the Olur Project and Ayvalı Project should be implemented simultaneously and both projects should be commissioned by the middle of 2006.

5) The Oltu project is planned as the most efficient power generation scheme to effectively utilize the head existing between the vicinity of EL. 1,100 m and the water level of Yusufeli Reservoir, EL. 710 m, based on the Master Plan for the Oltu River Basin. River gradients are steep in this area, and hard rock is exposed at both banks with the topography very rugged so that the area has site characteristics favourable for formulating dam-and-waterway type plans combining reservoirs and tunnels. Comparisons were made of two-stage, three-stage, and four-stage proposals and with power station locations varied, and the present two-stage development Basic Project Plan of the Olur project, OPK Alternative, and the Ayvalı Project, APU Alternative, was selected as being most advantageous.

6) Regarding the Olur Project, two dam sites and four powerhouse sites were selected for the Olur Project and comparison studies were made. The upstream site was chosen for the dam, and the downstream most OPK site for the powerhouse location. The headrace length would be approximately 9 km is length.

Regarding the Ayvıl Project with the dam site as a single location, comparison studies were made of four sites for the powerhouse, including both underground and above-ground types, and the most economically advantageous dam-underground powerhouse (APU site) - tailrace (approximately 10 Km is length) alternative was selected. This alternative was adopted due to the necessity of passing through the bedrock under the river bed of the Anzav Valley.

7) Various comparison studies were made regarding high water level and scale of reservoirs taking into consideration sedimentation and effective storage capacities of reservoirs. As a result high water level of EL. 1,105 m and effective storage capacity of 200 x $10^6 m^3$ was selected for the Olur project and high water level of EL. 930 m and effective storage capacity of 150 x $10^6 m^3$ was selected for the Ayvalı project.

8) Regarding the optimum scale of the Oltu Project, comparison studies were made by varying maximum discharges in case of equivalent peak duration hours of 6 hours, 8 hours and 10 hours.

As the results the case of equivalent peak duration hours of 6 hours is optimum for both the Olur and the Ayvalı Project. Therefore Optimum Scale of the Olur and Ayvalı Projects are 65 MW and 125 MW respectively.

9) The geology of Olur Reservoir consists of gabbro, spilite, and green schist of the Yusufeli Formation, lava and tuff of Ayvalı volcanic rocks, mudstone, marl, sandstone, and conglomerate of the Cenzoic Tertiary Period Oltu Formation, and Quaternary deposits.

There will be no problem regarding the water-tightness of the reservoir, while large-scale landslides at slopes in the reservoir area do not exist.

The geology at the site of Olur Dam consists of granite porphyry, rhyolite, diabase, and river deposits, and there is ample bearing power as the foundation for a rockfill dam of height 136 m. It is considered that the impermeability of the foundation rock can be easily secured with ordinary cement grout.

10) Regarding the type of Olur Dam, a central impervious core rockfill dam was selected as being economically advantageous upon comparison studies considering topography, geology, meteorology, materials, etc. The height of the dam is to be 136 m and the dam volume 3.8 x 10^6 m^3.

Of embankment materials, soil materials are to be collected from Kaledibi Borrow Area approximately 3 km upstream of the dam and Yolboyu Borrow Area 8 km upstream and used upon gradation adjustments. Riverbed sand-gravel excavated from the dam site is to be used as fine-grained filter, and excavated rock of higher content of fines is to be used as coarse-grained filter.

Rock materials are to be collected from a quarry at the right bank 10 km downstream from the dam and used for embankment.

The spillway is to be a chute type with flip bucket at the right bank having 3 gates, and the flood discharge capacity is to be the PMF of 4,750 m^3/s.

11) The intake is to be approximately 170 m upstream of the dam and is to be an inclined type. The power discharge of the power station is to be 48 m^3/s. The headrace route was selected to be as short as possible between the dam and powerhouse while taking into consideration topography, geology, work execution properties, and safety. The inside diameter and length of the headrace are 4.9 m and 9,659 m,

respectively. A restricted orifice type was adopted for the surge tank. The penstock is to be a surface type. The diameters are from 4.9 to 3.2 m, while the length is 436 m.

12) The powerhouse of Olur Power Station was selected to be an above-ground type giving consideration to topography, geology, work execution properties, access road, and the economics. The number of main equipment units was made one unit considering the scale of the electric power system of Turkey at the time of development, and the turbine and the generator are to be a vertical-shaft Francis turbine (65 MW) and a 3-phase, alternating-current synchronous generator (74,000 kVA).

The switchyard of the Olur Project is to be an outdoor type and provided adjacent to the powerhouse.

The electric power generated at Olur Power Station is to be sent to Yusufeli Switchyard via Ayvalı Switchyard by a 154 kV transmission line, and upon step-up to 380 kV, it is to be sent to load areas by 380 kV transmission line.

13) The geology of Ayvalı Reservoir consists of Ayvalı volcanic rocks of lava, rhyolite, tuff, and volcanic breccia, the Pugey Formation of alternations of mudstone, marl, and limestone, and Quaternary deposits.

There is practically no possibility of leakage in the geology of the reservoir surroundings. The scales of landslides at the slopes around the reservoir are small and are not of a degree to impair the safety of the reservoir.

The geology at the site of Ayvalı Dam consists of volcanic breccia, tuff breccia, tuff, rhyolite, and river-bed deposits, and there is sufficient bearing power as the foundation for a rockfill dam of height about 175 m. It is considered that securing impermeability of the foundation rock is amply possible with ordinary cement grout.

14) Regarding the type of Ayvalı Dam, a central impervious core rockfill dam was selected as being economically advantageous upon considering topography, geology, meteorology, materials, etc. The height of the dam selected is to be 175 m, and the dam volume 9.3 x 10^6 m^3.

Of embankment materials, soil materials are planned to be obtained from borrow areas at the Bulanik Valley 8 km downstream from the dam and the Tavusker Valley 8 km upstream, and the materials collected from these borrow areas are to be used for embankment upon adjustment of grain sizes. For fine-grained filter, sand-gravel excavated from the dam site, and for coarse-grained filter, excavated rock of higher content of fines is to be used.

Rock materials are to be collected at a quarry site on the left bank upstream of the dam, transported, and banked. The spillway is to be a chute type with flip bucket at the right bank and having 3 gates. The flood discharge capacity is to be sufficient for PMF of 5,270 m^3/s.

15) The intake of the Ayvalı Project is to be an inclined type equipped with gate provided at the left bank approximately 100 m upstream from the dam. The power discharge of the power station is to be 67 m^3/s. The penstock continuing from the intake is to be a buried type. The diameters are to be from 4.1 to 3.8 m, and the length 288 m. The powerhouse of Ayvalı Power Station was selected to be an underground type from the standpoint of the layout of the waterway system. The bedrock at the left bank in the vicinity of the dam is considered to be capable of amply withstanding excavation of a large cavern for an underground powerhouse. The underground powerhouse and Yusufeli Reservoir are to be connected by a standard

horseshoe-shaped tailrace tunnel of diameter 5.4 m and length 9,261 m.

16) The number of main equipment units of Ayvalı Project is to be one unit according to the same thinking as for Olur Power Station with a turbine of vertical-shaft Francis turbine (125 MW) and a generator of 3-phase, alternating current synchronous generator (140,600 kVA). A main transformer is installed in the powerhouse. The switchyard of the Ayvalı Project is to be an outdoor type with the powerhouse and the switchyard connected by a 154 kV x 1 cct XLPE cable transmission line. The electric power generated at Ayvalı Power station is to be sent to Yusufeli Switchyard by 154 kV transmission line, and upon step-up, sent to load areas by 380 kV transmission line.

17) Total construction cost including foreign and local currencies of the Oltu Project is 1,635,052 x 10^6 TL (US$ 380.3 x 10^6). Total construction cost including foreign and local currencies of the Olur project and Ayvalı Project is 677,364 x 10^6 TL (US$ 157.5 x 10^6) and 957,688 x 10^6 TL (US$ 222.7 x 10^6) respectively.

18) The environmental impact assessment was made based on field investigations and data collection during a short period of time, and there is hardly anything to be found in the results of studies against development of this Project. Further, from the points of view of electric power supply and regional development the Project should be aggressively developed. However, thorough consideration should be given to the people living in the area with regard to agricultural land to be submerged in the reservoirs and to other related matters.

19) For the purpose of benefit-cost analysis, an imported-coal fired thermal power plant capable of substituting the Project was assumed, and the costs compared. The result of

the study indicated that the net present value (B - C) and the benefit cost ratio (B/C) of the Oltu Project are 538,944 x 10^6 TL (US$125.3 x 10^6) and 1.54 respectively.

And the net present values (B-C) and the benefit cost ratios (B/C) of Olur and Ayvali Projects are 137,774 x 10^6 TL (US$32.0 x 10^6), 1.33 and 401,170 x 10^6 TL (US$93.3 x 10^6) 1.71 respectively.

20) The economic internal rate of return (EIRR) was calculated by the modification market price (conversion to border price), which was obtained by modifying the market price used in the FIRR. The discount rate at which the present values of the investments on the Project and on the alternative thermal power plant becomes equal in the first year of the projects, is 26.82%. Thus it can be concluded that the Project is superior unless to discount rate does not exceed 26.82%.

The financial soundness of the Project was evaluated by comparing the financial internal rate of return (FIRR) based on the market prices with the borrowing interest rate expected for the Oltu Project. The financial internal rate of return of the Project is 10.68%, exceeding the expected borrowing interest rate of 9.5%.

Thus it can be concluded that the Project is feasible from both economic and financial points of view.

The economic internal rate of return (EIRR) and financial rate of return (FIRR) of the Olur and Ayvalı projects are 18.72%, 9.87% and 33.05%, 11.25% respectively.

RECOMMENDATIONS

The Olur and Ayvalı Projects are technically and economically feasible, and it is recommended that they be developed.

For realization of the Project it is necessary for the following to be implemented:

(1) It is necessary for the various preparations needed for construction such as definite designs and production of tender documents to be made.

(2) For carrying out definite designing, additional investigations and testing are needed regarding the items listed in Chapter 16, "Further Investigations," and the results must be amply reflected in the detailed designs.

(3) It is necessary for concrete relocation plans to be formulated regarding the national highway to be affected by implementation of this Project.

(4) It is necessary to set up concrete plans regarding relocation of approximately 4,200 people to be affected by submersion due to implementation of this Project.

(5) To satisfy energy demand, the Oltu Project should be developed as soon as possible. Therefore the start of construction work for the Oltu Project will be beginning of 2000. The start of operation of the Olur Power Station will be at the end of 2005 and that of Ayvalı Power Station in the middle of 2006.

Chapter 1 INTRODUCTION

Chapter 1

INTRODUCTION

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Chapter 1 INTRODUCTION

INTRODUCTION

The Republic of Turkey had developed in the past as an agricultural country, but in recent years it has switched emphasis to industrialization and efforts are being continued for growth of the national economy. Providing energy, particularly electric energy, is of great importance for industrialization, and the Turkish Government has given priority to development of domestic energy resources, and efforts are being made for development of lignite-burning thermal power and hydroelectric power based on purely indigenous resources.

Growth in GNP and growth of electric power will be more or less proportionate when industrialization progresses. Up to around 1980, this relationship was not necessarily linear in Turkey because of the shortage of electric power facilities, but with the favorable development of the Turkish economy on entering the 1990s, the relationship has become roughly linear. The growths in population, GNP, and electric power supply from 1979 to 1990 are given below.

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1987	1988	1989	1990
GNP growth (%)	-0.4	-1.1	4.2	4.5	3.3	5.9	5.1	8.1	7.5	7.5	3.6	1.9	9.2
Electric Energy Supply Growth (%)	5.5	4.5	6.8	7.7	4.4	12.5	9.3	11.3	11.0	11.0	7.8	8.6	9.5

The Turkish economy up to 1983 had been sluggish having been affected by the second oil crisis which occurred in 1978, but picked up from around 1984 and since then development has been favorable, and this has been indicated by the smooth growth in electric power demand.

1.1 Background of the Project

As principal energy resources produced in the Republic of Turkey, there are the 5.7 x 10^6 ton of petroleum reserves, 12.9 x 10^9 ton of lignite reserves and 30,800 MW of hydroelectric potential. Of this hydroelectric potential, only 6,755 MW, 22%, had been developed as of the end of 1990, and there is much being expected of development hereafter of this clean and purely domestic energy resource.

The installed capacity for power generation as of the end of 1990 consisted of 9,519 MW in thermal power plants and 6,755 MW in hydroelectric power station facilities for a total output of 16,274 MW. The Turkish Government, as a long-range outlook, has forecast an electric power demand of approximately 120,000 GWh (annual growth rate 8%) in 2000 A.D. and 258,000 GWh in 2010 (annual growth rate 8%), and has planned an annual development quantity of an average of 30,000 MW of which hydroelectric development would be an average of 15,000 MW.

The energy resources of Turkey were said in the Annual Report of 1983 to be 5.7 x 10^6 ton of petroleum, 12,900 x 10^6 ton of coal, and 30,800 MW of hydroelectric potential. The production of petroleum is only about 10 to 20 percent of the domestic demand. Production of coal is about 20 x 10^6 ton annually, but there is little hard coal, with the greater part made up of lignite which is not of as good quality as coal, and it is difficult for this to be used for other than fuel. Therefore, hard coal is used for industrial purposes, and lignite for heating and thermal power stations.

On the other hand, with regard to hydro power, in spite of being in a dry region, because of the characteristic that the entire country of Turkey is in the form of a plateau, the hydroelectric potential is fairly abundant, and from the fact that it is a purely indigenous energy resource, the Turkish Government has been aggressively pushing ahead with development. From the point